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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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VOLUME 55

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R. C. CORLEY, Editor

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Sixty-First Annual Meeting
BUTLER UNIVERSITY
October 18, 19 and 20, 1945

Copies of the Proceedings may be purchased through the State Library, Indianapolis, Indiana, at $3.00 per volume. All items sent in exchange for the Proceedings and all communications to officers of the Academy, when their names and addresses are not known, should also be sent to the State Library.

Reprints of certain parts of recent volumes of the Proceedings are available for distribution as follows: copies of the constitution and by-laws (Vol. 44), and complete membership list (Vol. 50), may be secured by members elected subsequent to the publication of those volumes; copies of the codified list of duties of officers (Vol. 48) may be secured by officers, divisional chairmen, and chairmen of committees; and copies of the necrology can be supplied to relatives and friends of the deceased members. Inquiries concerning these reprints should be addressed to the Secretary of the Academy, Dr. Winona H. Welch, DePauw University, Greencastle, Indiana.

Reprints of technical papers in recent volumes can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

Application blanks for membership are available from members of the Membership Committee or from the Secretary.

Excerpts from the Constitution of the Indiana Academy of Science

Article I.

Sec. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science. The Academy shall promote intercourse between men engaged in scientific work, especially in Indiana, assist by investigation and discussion in developing and making known the educational, material and other resources and riches of the state, prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

Article II.

Sec. 2. Any person interested in any department of scientific work shall be eligible to membership. They shall pay an admission fee of one dollar and one dollar dues and thereafter an annual fee of one dollar.

Sec. 4. The Indiana Academy of Science shall actively promote the organization and operation of local science clubs in connection with secondary schools of the state. Such of these clubs as elect to become members shall constitute the Indiana Junior Academy of Science.

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OFFICERS AND COMMITTEES FOR 1945

OFFICERS

President, M. S. MARKLE, Earlham College.

Vice-President, J. F. MACKELL, Indiana State Teachers College.

Secretary, WINONA H. WELCH, DePauw University.

Treasurer, W. P. MORGAN, Indiana Central College.

Editor, R. C. CORLEY, Purdue University.

Press Secretary, C. M. PALMER, Butler University.

Trustees of Academy Foundation: J. S. WRIGHT, Eli Lilly & Company (term expires 1948), chairman; F. B. Wade, Shortridge High School (term expires 1947).

Committee for Bonding of Trustees: R. C. FRIESNER, Butler University chairman; Scott McCoy, Indianapolis.

Research Grant Committee: T. G. YUNCKER, DePauw University (term expires 1949) chairman; H. E. ENDERS, Purdue University, (term expires 1945); A. L. FOLEY, Indiana University, (deceased 2-13-1945), (term expires 1946); E. G. MAHIN, University of Notre Dame, (term expires 1947); J. S. WRIGHT, Indianapolis, (term expires 1948); M. S. MARKLE, Earlham College, (ex officio); Winona H. Welch, DePauw University, (ex officio).

DIVISIONAL CHAIRMEN

Anthropology, J. C. HOUSEHOLDER, Indianapolis.
Bacteriology, C. M. PALMER, Butler University.
Botany, R. E. GIRTON, Purdue University.
Chemistry, C. W. HOLL, Manchester College.
Geology and Geography, E. R. SMITH, DePauw University.
History of Science, JOHN S. WRIGHT, Indianapolis.
Mathematics, JUNA L. BEAL, Butler University.
Physics, R. E. MARTIN, Hanover College.
Psychology, W. N. KELLOGG, Indiana University.
Zoology, W. R. BRENEMAN, Indiana University.

EXECUTIVE COMMITTEE

(Past Presidents, Officers, Divisional Chairmen, and Chairmen of Standing Committees)

Juna L. Beal, C. A. Behrens, W. R. Breneman, S. Burrage, O. B. Christy, W. A. Cogshall, R. C. Corley, E. R. Cumings, J. J. Davis, C. C. Deam, W. E. Edington, H. E. Enders, R. C. Friesner, W. G. Gingery, R. E. Girton, C. W. Holl, J. C. Householder, Theodor Just, W. N. Kellogg,

Eli Lilly, J. F. Mackell, E. G. Mahin, C. A. Malott, M. S. Markle, E. S. Martin, R. E. Martin, M. G. Mellon, W. P. Morgan, C. M. Palmer, F. Payne, J. E. Potzger, R. R. Ramsey, W. E. Ricker, E. R. Smith, J. E. Switzer, F. B. Wade, F. N. Wallace, Paul Weatherwax, Winona H. Welch, J. S. Wright, T. G. Yuncker, H. L. Bruner (deceased 3-17-1945).

BUDGET COMMITTEE

(President, Secretary, Teasurer, Editor, and Chairmen of Committee on Relation of Academy to State, Program Committee, and Library Committee)

M. S. Markle, R. C. Corley, W. G. Gingery, W. P. Morgan, J. E. Potzger, F. N. Wallace, Winona H. Welch.

STANDING COMMITTEES

(Appointed by the President, Chairman of each committee named first)

Auditing: E. S. Martin, K. S. Means.

Biological Survey: W. E. Ricker, R. M. Kriebel, W. P. Allyn, H. O. Deay, H. H. Michaud, B. E. Montgomery, C. M. Palmer, Dorothy Parker, Winona H. Welch.

Invitations: C. M. Palmer, A. R. Bechtel, Edward Kintner, Fred Loew, S. S. Visher.

Junior Academy of Science: H. E. Enders, W. P. Allyn, O. B. Christy, F. R. Elliott, M. S. Markle, C. L. Porter, F. B. Wade, M. M. Williams, T. G. Yuncker.

Library: W. G. Gingery, Nellie M. Coats, R. C. Friesner.

Membership: J. E. Switzer, G. F. Hennion, W. E. Martin, J. E. Potzger.

Nominations: H. E. Enders, F. Payne, T. G. Yuncker.

Program: J. E. Potzger, Juna L. Beal, May Iske, Charles C. Josey.

Publication of Proceedings: R. C. Corley, P. D. Edwards, Paul Weatherwax.

Relation of Academy to State: F. N. Wallace, E. Y. Guernsey, Eli Lilly, H. J. Reed, J. S. Wright.

Representative on Council of A.A.A.S.: H. E. Enders.

Resolutions: O. B. Christy, Theodor Just, Naomi Mullendore.

SPECIAL COMMITTEE

Fifty Year Index: Ray C. Friesner, Nellie M. Coats, W. P. Morgan, F. N. Wallace, Paul Weatherwax.

PROGRAM OF THE WINTER MEETING

BUTLER UNIVERSITY

October 18-20, 1945

THURSDAY, OCTOBER 18

7:30 P. M.

Meeting of the Executive Committee

FRIDAY, OCTOBER 19

9:30 A. M. General Session

Address of Welcome. Dr. C. R. Maxam, Registrar, Butler University.

Response. President Millard S. Markle.

Necrology W. E Edington, DePauw University.

Indiana Scientists Sketched in American Men of Science. H. E. Zabel and Stephen S. Visher, Chicago, Illinois, and Indiana University.

Sand. Ernest Rice Smith, DePauw University.

EXHIBIT—

1. Miss Nellie Coats, New materials in the Academy Library

11:45 A. M. and 2:30 P. M. Sectional Meetings

6:30 P. M. Annual Dinner

Business Session.

President's Address. "Biology and the Postwar World." President Millard S. Markle, Earlham College.

SATURDAY, OCTOBER 20

9:00 A. M.

Taxonomists Meeting

Entomologists Meeting

Junior Academy of Science

MINUTES OF THE EXECUTIVE COMMITTEE

INDIANAPOLIS, October 18, 1945

The Executive Committee was called to order by President Markle at 7:50 p.m., in Lincoln Room, Hotel Lincoln. Approximately forty members were in attendance. The reports of officers and committee representatives were presented and accepted as follows:

Academy Trustee. Report of John S. Wright, Frank B. Wade, and W. P. Morgan, Trustees of the Foundation Fund, Indiana Academy of Science, for the year 1944-1945.

Balance from the previous year	$ 73.76
Total receipts	171.55
Bonds called	100.00
Total	$ 345.31
Expenditures—Union Trust Co. Fee 5% on $253.68	12.69
Cash balance at Union Trust Company	$ 332.62

Assets in the Fund as of October 28, 1945

Five $1,000 U. S. Savings Bonds Series "D", Cost	$ 3,750.00
$6,400 U. S. Treasury Series "G" Bonds, Cost	6,400.00
Six shares Standard Oil of Indiana Common Stock, par	150.00
Total at par or cost	$10,300.00

Auditing Committee. E. S. Martin stated that the accounts of the Academy Trustees and the Treasurer have been carefully checked and found in good order.

Treasurer. W. P. Morgan presented a tentative financial report for the period from January 1 to October 1, 1945. His final report, approved by the Auditing Committee at the end of the year follows:

Receipts

Balance on hand January 1, 1945	$1,814.54	
Dues and initiation fees	882.00	
Research grant refunded by administrator of Dr. Foley's estate	75.00	
Author's reprints, Vol. No. 51	20.56	
Author's reprints, Vol. No. 52	8.25	
Author's reprints, Vol. No. 53	144.75	
Gift memorial to Dr. H. L. Bruner	25.00	
Designated gift	500.00	
Publications sold by Librarian	6.00	
		$3,476.10

Disbursements

1—Program Committee	$ 124.27	
2—Editor	200.00	
3—Expenses of Secretary	45.96	
4—Expenses of Treasurer	71.00	
5—Mailing Proceedings	34.88	
6—Stationery	42.41	
7—*Preparation of fifty-year index	70.00	
8—Surety Bond	25.00	
9—*Preparation "Indiana Men of Science"	3.50	
10—*Foundation Fund	25.00	
11—Research grant, J. A. Potzger	25.00	
12—Research grant, Kenneth Wagner	50.00	
13—Postage refund, R. E. Girton	2.70	
14—Returned checks	9.00	
15—Cost of reprints, Vol. No. 54	403.90	
		$1,132.62
†Balance on hand		2,343.48
		$3,476.10

* Paid from funds provided by designated gifts.

† Balance includes $996.25 in gifts designated for the completion of work on the fifty-year index and the preparation for publication of the "Indiana Men of Science."

(Signed) W. P. Morgan, *Treasurer.*
(Signed) ERSIE S. MARTIN } *Auditors.*
(Signed) KARL S. MEANS }

Bonding Committee. R. C. Friesner reported that the Academy carries with the Hartford Accident and Indemnity Co. bonds in the amount of $2000.00 for the Treasurer and $5000.00 each for the Trustees. These are renewable annually at a total cost of $25.00. Expiration date is November 18. The Executive Committee authorized the continuance of the bonds.

Editor and Publication of Proceedings. R. C. Corley reported an order of 1600 copies of the Proceedings and 7650 reprints.

Research Grant Committee. T. G. Yuncker announced that seven grants are in use at the present time.

Biological Survey. W. E. Ricker reported that the members of the committee were continuing their work.

Fifty-Year Index. R. C. Friesner reported the completion of the indexing. Proof reading would be started within a few days.

Library Committee. W. G. Gingery presented a report prepared by Nellie M. Coats, Academy Librarian. Ten years ago the work of the Academy Library was placed under the jurisdiction of the Catalog Division of the Indiana State Library. In 1935 there were 1030 bound volumes in the Academy Library. In 1945 the total number of bound volumes is 3801, with 217 now in the process of binding. There are 243 titles on the active list of serials. The library received as a gift from

Claude Lomax 13 volumes of ornithological periodicals. In plans presented to the Indiana Economic Council and to the State Building commission, the need for additional space for housing the library was pointed out and a request made for shelving space and for future office space for an Academy headquarters and for committee meetings in the State Library and Historical Building. The Executive Committee accepted this recommendation and authorized the Secretary to send a resolution to that effect to the Secretary of the State Building Commission.

Press Secretary. C. M. Palmer, in co-operation with the Publicity Office of Butler University, sent Academy news release to more than 250 newspapers in Indiana. The photographic file of Academy presidents and other officers is maintained as complete as possible.

Membership. J. E. Switzer presented a tentative report of 60 applications, as the final report and the election of members occur at the dinner meeting.

Junior Academy of Science. H. E. Enders announced the total of 52 Junior Clubs. Biology Club, William Wirt School, Gary, and Junior Academy Club, Franklin High School, Fort Wayne, were presented for affiliation with the Academy.

Relation of Academy to State. F. N. Wallace reported that the Budget Committee recommended an annual appropriation of $1500.00, and the Legislature passed the appropriation.

Relation of Academy to A.A.A.S. No meeting of A.A.A.S. has been held since the last meeting of the Academy.

Nominations. H. E. Enders presented the following names for election as Fellows at the business meeting on Friday: Arthur F. Bentley, William D. Gray, Henry B. Hass, Alfred H. Meyer, and Andrey A. Potter. To the Research Grant Committee, Paul Weatherwax was nominated to complete the term of A. L. Foley, (term expiring in 1946) and H. H. Remmers to replace H. E. Enders, (term expiring in 1945). (It was Dr. Enders' personal request not be continued on the committee.) R. C. Friesner, Chairman, and Scott McCoy were nominated to succeed themselves on the committee of Bonding of Trustees.

Old Business. W. E. Edington made a progress report for the Committee on History of Science in Indiana. T. G. Yuncker, reporting for the committee appointed to canvass the possibility, of securing the affiliation of scientific organizations in Indiana with the Academy of Science, stated that no organization is interested in such affiliation at this time, and added that inasmuch as the method by which an organization may unite with the Academy has been established the members of this committee propose that said committee be discharged and that any officer or member of the Academy be free to suggest such an affiliation when deemed proper.

New Business. J. S. Wright read a letter from Mrs. H. L. Bruner in which Mrs. Bruner had sent a check for the Academy Foundation

Fund in memory of her husband and his interest in the Academy. The gift was accepted and the Secretary instructed to send a letter of thanks and appreciation to Mrs. Bruner.

J. S. Wright read the following resolution to the committee:

A RESOLUTION petitioning Congress to enact laws to effectuate the plans for a memorial to Benjamin Harrison, and to provide the necessary funds therefor.

WHEREAS, the Benjamin Harrison Memorial Commission has transmitted its report in compliance with the provisions of Section 3, Public Law No. 352, Seventy-sixth Congress, approved August 9, 1939, said report having been submitted March 21, 1941, published as House Document 154, Seventy-seventh Congress, first session and referred to the committee on the library for a suitable memorial to Benjamin Harrison;

WHEREAS, the plans as recommended will advance the conservation program in Indiana by at least one generation by accelerating the forest restoration program; and

WHEREAS, the plans are in keeping with sound postwar work; and

WHEREAS, the plan combines wise use of government money with a long range program of investment by creating a memorial of usefulness and beauty; and

WHEREAS, the proposed Harrison Memorial requires the approval of the Congress of the United States to effectuate the plan; Therefore

SECTION 1. BE IT RESOLVED BY THE INDIANA ACADEMY OF SCIENCE, an organization of nearly one thousand members representing the various scientific interests of the state, at its SIXTY-FIRST ANNUAL MEETING hereby petitions the Congress of the United States to enact into law H.R. 4006, which was introduced into the Seventy-ninth Congress, so as to effectuate the plans for a memorial to Benjamin Harrison, and to provide the needed funds for accomplishing the plans as heretofore recommended by the Benjamin Harrison Memorial Commission in its report made to the Seventy-seventh Congress, first session.

SECTION 2. That a certified copy of this resolution be sent by the secretary of the Indiana Academy of Science to the clerk of the house of representatives and to the secretary of the senate of the Seventy-ninth Congress, and to each United States senator and representative from Indiana.

The resolution was adopted and the Secretary instructed to send certified copies of same to the authorities listed in the Resolution.

It was voted to resume the holding of Spring meetings in 1946. Because of World War II no Spring meetings were held in 1943, 1944, and 1945.

The chairman of the Fifty-year Index is to be included on the Academy Budget Committee until the Index is published.

A motion was made by H. E. Enders to strike the following sentence from the By-Laws, Art. 2, Sec. 3: "Of members so nominated a number not exceeding five in any one year may, on recommendation of the Executive Committee, be elected as fellows." The motion was seconded and the recommendation carried, the item to be presented to the General Business Session Friday morning.

A motion was made by T. G. Yuncker that the President of the Academy follow the principle of continuing one member of the Nominating Committee of the previous year, for the sake of continuity of ideas presented in the committee. Motion was seconded and adopted.

Meeting adjourned at 10:10 p. m.

MINUTES OF THE GENERAL SESSION

BUTLER UNIVERSITY, October 19, 1945

Dr. C. R. Maxam, Registrar, Butler University, delivered the Address of Welcome. President Markle responded in behalf of the Academy.

W. E. Edington presented the Necrology.

Minutes of the Executive Committee meeting of October 18, 1945, were read by the Secretary and approved by the Academy. H. E. Enders explained to the General Session the reason for the proposed change in the By-Laws. F. B. Wade moved that the By-Laws be changed as recommended by the Executive Committee. J. F. Mackell seconded the motion. It was voted that the sentence be stricken from the By-Laws.

Following the annual dinner in the Travertine Room, Hotel Lincoln, J. E. Switzer presented ninety-six applications for membership. The Secretary was instructed to cast an unanimous ballot for the ninety-six applicants.

H. E. Enders read the nominations of the committee as follows: *President,* E. F. Degering, Purdue University; *Vice-President,* N. E. Pearson, Butler University; *Secretary,* Winona H. Welch, DePauw University; *Treasurer,* W. P. Morgan, Indiana Central College; *Editor,* R. C. Corley, Purdue University; and *Press Secretary,* C. M. Palmer, Bulter University.

The Divisional Chairmen elected in the sectional meetings for 1946 were announced as follows *Anthropology,* Wm. B. Adams, Bloomington; *Bacteriology,* F. A. Miller, Eli Lilly & Co., Greenfield; *Botany,* J. E. Potzger, Butler University; *Chemistry,* E. F. Degering, Purdue University; *Geology and Geography,* G. D. Koch, Indiana State Teachers College, Terre Haute; *History of Science,* W. E. Edington, DePauw University; *Mathematics,* H. E. Wolfe, Indiana University; *Physics,* K. W. Meissner, Purdue University; *Psychology,* C. C. Josey, Butler University; and *Zoology,* H. H. Vogel, Jr., Wabash College.

C. M. Palmer announced that the Committee on Invitations had accepted the invitation of Indiana State Teachers College, Terre Haute, for the 1946 Fall Meeting of the Academy.

O. B. Christy expressed on behalf of the Academy its sincere appreciation and thanks to the faculty of Butler University, the management of the Hotel Lincoln, to the program committee, the committee on Junior Academy of Science, and to the officers of the Indiana Branch of the Soicety of American Bacteriologists and the Indiana Section of the Mathematical Association of America for their willingness to join in the Academy program.

Vice-President Mackell introduced President Markle who delivered a splendid address on "Biology and the Postwar World."

The 61st annual meeting of the Indiana Academy of Science, with a general attendance of 281 and a dinner attendance of 124, was adjourned.

WINONA H. WELCH, *Secretary.*

TAXONOMISTS MEETING

J. E. POTZGER, Butler University, Chairman

The Plant Taxonomists held their meeting on Saturday morning at Butler University. A. T. Guard, Purdue University, was elected chairman for 1946, and Naomi Mullendore, Franklin College, Secretary.

ENTOMOLOGISTS MEETING

RALPH MORRIS, Assistant State Entomologist, Chairman

Glen E. Lehker, Purdue University, was elected chairman for 1946.

ADDITIONAL NEW MEMBERS, 1944

Bolander, Mr. Lester M., 1226 N. Temple Ave., Indianapolis 1 C
Coon, Mr. Jesse B., 624 E. 8th, Bloomington ..... Ph
Edmondson, Dr. Frank K., 716 S. Woodlawn, Bloomington ..... As
Feinberg, Mr. Mortimer, Science Hall, Psych. Dept., Indiana U., Bloomington ..... Ps
Garst, Miss Virginia L., De Soto ..... Bo
Hamilton, Mr. Dan K., 531 Federal Bldg., Louisville 2, Ky. ..... G
Hart, Mr. Donald M., Dept. of Chemistry, Indiana University, Bloomington C
Hire, Dr. Charles, Dept. of Physics, Indiana University, Bloomington .. Ph
Hornaday, Mr. Raymond, 578 M. D. Woodruff Place, Indianapolis 1 ... Ph
Klaer, Jr., Mr. Fred H., 3835 N. New Jersey St., Indianapolis 5 ..... G
Wynd, Dr. F. L., University of Illinois, Urbana, Illinois ..... Bo
Zicroff, Sister Gertrude Marie, O.S.F., 3600 Cold Springs Rd., Marian College, Indianapolis 44 ..... M

NEW MEMBERS, 1945

Adams, Dr. S. Clifford, Box 194, Hanover ..... G
Akers, Mr. Eugene, 621 Highwood Ave., Greencastle ..... Bo, C
Bailey, Mr. James C., 246 N. Smart St., Greenwood ..... General
Barton, Mrs. Mary F., 6048 Carrollton Ave., Indianapolis ..... Nature
Bechert, Mr. Charles H., 1207 N. Wallace St., Indianapolis ... Hydrology
Bergdall, Miss Irene F., 2306 College Ave., Huntington ..... M
Bogarosh, Mr. Peter L., 318 Warren St., Phillipsburg, New Jersey .... Bo
Bohnenblust, Prof. Henri Frederic, 714 East 9th St., Bloomington ..... M
Buehler, Mr. John A., Chemistry Dept., Indiana U., Bloomington C
Burkett, Prof. Howard B., 325 Highfall Ave., Greencastle C
Carnahan, Prof. Walter H., 708 Vine St., West Lafayette ..... M
Christian, Dr. John Edward, 825 N. Main St., West Lafayette C
Christman, Mr. John F., 525 South 6th St., Terre Haute C
Churchill, Mr. Paul K., 2928 Washinton Blvd., Indianapolis 5 ..... Ph
Clark, Mr. James A., 700 Montomery Ave., Jeffersonville ..... E
Cole, Dr. Versa V., 1040 W. Michigan St., Indianapolis ..... Pharm.
Conklin, Dr. Raymond L., 1906 E. Jackson Blvd., Elkhart ..... Ba, C, Ps
Cook, Dr. Donald J., 415 E. Walnut, Greencastle C
Cougill, Mr. Kenneth R., 811 Berkley Road, Indianapolis ... Conservation
Cox, Mr. Alvalon Conway, 2948 Indianapolis Ave., Indianapolis ..... Ph
Deese, Mr. James, 1357 E. Tenth St., Bloomington ..... Psy
Deiss, Prof. Charles F., 819 East 8th St., Bloomington ..... G
Delks, Miss Patricia, 31 N. Bolton Ave., Indianapolis 1 ..... A
DeMoss, Prof. Lowell H., Central Normal College, Danville ..... B
Elbinger, Mrs. Rebecca L., 2521 Elmhurst, Detroit, Michigan C
Everts, Miss Marilyn, 326 W. Crawford St., Elkhart ..... C-B
Goebel, Mr. Harold John, 701 W. Packard Ave., Fort Wayne ..... B

Golbach, Mr. Richard, 4703 Guilford Ave., Indianapolis 5 ..... Everything
Grandy, Mrs. Gladys E., 717 E. 52nd St., Indianapolis ..... Gen Sci
Gries, Dr. George A., 901 W. Stadium Ave., West Lafayette ..... Bo
Hadley, Prof. Alden H., 203 W. High St., Mooresville ..... B
Hanske, Mr. Carl F., 901 N. Bolton Ave., Indianapolis ..... B-C
Harrison, Mrs. Anne Butler, 48 S. Downey Ave., Indianapolis 1 ..... Orn
Heppel, Miss Ruth E., 626 S. Norman Ave., Evansville 14 ..... Bo
Higinbotham, Dr. Noe, 311 North Williams St., South Bend 5 ..... Bo
Hinchman, Mr. Max, 303 W. Fourth St., Greenfield ..... B
Hine, Dr. Maynard K., 327 Buckingham Drive, Indianapolis ..... Dentist
Huddleston, Mrs. Frances, 557 Jackson St., Gary ..... B
Hurlbut, Miss Zylpha D., 121 N. Tillotson Ave., Muncie ..... B
Hyde, Miss Julia, 666 E. Jefferson St., Franklin ..... B-C
James, Prof. Charles M., 136 DeHart St., W. Lafayette ..... Z
Jeffers, Miss Vivian D., 337 Elm Street, Lawrenceburg ..... B
Kelly, Miss Mary Frances, 5932 Oak Avenue, Indianapolis ..... A
Ketchum, Mrs. Helen M., 217 Park Ave., Elkhart ..... Bac
Knapp, Mr. Virgil R., Zionsville ..... E
Krumholz, Dr. Louis A., 730 E. Hunter Ave., Bloomington ..... Z
Larson, Dr. Raymond G., 255 S. College Ave., Valparaiso C
Liaptcheff, Mr. K. K., Dept. of Zoology, Indiana U., Bloomington ..... Z
Lillard, Prof. Richard G., Route 3, Bloomington ..... Geog
Livingston, Mr. William Arnold, 427 S. Henderson St., Bloomington ..... Psy
Lorz, Dr. Albert P., R.R. 10, Lafayette ..... Genetics
Malm, Dr. Marguerite, Union Bldg., Indiana State Teachers College, Terre Haute ..... Psy
Martindale, Miss Evelyn C., Box 33 Manchester College, North Manchester ..... C-B
McClain, Mr. John A., 601 N. East, Greenfield ..... B
McCreery, Mr. Gene S., 402½ S. Talley Ave., Muncie ..... C-B
McDougal, Mr. Russell, 2515 Deming St., Terre Haute ..... C, B, Ph
McKinney, Mr. Gordon R., 925 Eugene St., Indianapolis 8 ..... Z
Meibohm, Mr. A. W., 455 South Greenwich, Valparaiso C
Meissner, Dr. K. W., 216 South Chauncey Ave., West Lafayette ..... Ph
Morris, Dr. D. W., 2730 Wilson Drive, Terre Haute ..... Speech
Olsen, Miss Florence M., 705 5th St., Devils Lake, North Dakota ..... Ph
Passel, Mr. Charles F., Dept. of Geology, Indiana U., Bloomington ..... G
Peak, Mr. Philip, 610 North Faculty, Bloomington ..... M
Phillips, Mr. William F., 826 Collett Ave., Terre Haute C
Prange, Mr. Henry C., 5721 Haverford Ave., Indianapolis ..... Bo, G
Pruett, Mr. John Robert, 301 N. Jefferson St., Bloomington ..... Ph
Rowe, Dr. Edward J., 5819 E. Washington St., No. 8, Indianapolis 1 C
Sanders, Miss Dorothy W., Sandborn ..... B
Schmidt, Dr. Bernardine C., Special Education Clinics IST College, Terre Haute ..... Psy
Schwarz, Mr. W. M., 412 Ballantine, Bloomington ..... Ph
Scott, Mr. Donald C., 203 S. Washington, Bloomington ..... Z
Sheehan, Rev. Robert J., Dept. of Biology, Univ. of Notre Dame, Notre Dame ..... Z

Skinner, Dr. B. F., 824 Sheridan Rd., Bloomington ..... Psy
Sprinkle, Mr. Howard B., R.R. 3, Muncie C
Staab, Rev. C. J., St. Joseph's College, Collegeville ..... Ph
Stone, Mr. G. Raymond, 214 E. 6th St., Bloomington ..... Psy
Stuart, Mr. Elmer H., R.R. 6, Box 636, Indianapolis 44 C
Sturm, Dr. R. G., 1200 North Grant, West Lafayette ..... Eng
Suttle, Dr. John F., 508 E. 4th St., Bloomington C
Thomas, Prof. Tracy Y., North Fee Lane, R.R. 2, Bloomington ..... M
Toabe, Miss Ruth, 522 East Third St., Bloomington ..... Bact
VerHoef, Miss Shirley, 152 S. Home Ave., Franklin ..... B
Volk, Dr. N. J., 865 N. Salisbury, West Lafayette ..... Agri
Whitesel, Miss Grace, Butler University, Indianapolis ..... Home Econ
Wiggam, Dr. Albert E., Box 200, Vernon ..... B
Williams, Miss Jane, 4231, Carrollton, Indianapolis 5 ..... General
Williams, Prof. Kenneth P., 523 E. Third St., Bloomington ..... M
Williams, Miss Mary I., 316 Berkley Road, Indianapolis 8 ..... Eng
Wilson, Mr. Francis H., 1513 Alabama St., Lafayette ..... Anthro
Wirsching, Mr. Robt. F., 727 Nottingham St., Indianapolis ..... Engin
Wood, Miss Allyn Louise, 2502 North Alabama St., Indianapolis 5 ... B
Woofter, Dr. J. A., Taylor University, Upland ..... Psy
Wyse, Prof. Olive G., 1810 South Main St., Goshen ..... Home Ec

JUNIOR ACADEMIES

Biology Club of William A. Wirt School, Grand Blvd. at Birch St., Gary B
Franklin Junior Academy of Science, Archer and St. Mary's Ave.,
Fort Wayne .....

INDIANA JUNIOR ACADEMY OF SCIENCE

OFFICERS FOR 1942-1945*

President: Mary Ann Stout
Elkhart, Indiana

Vice President: Lloyd Nevel
Mishawaka

Secretary: James Smith
Central High School, South Bend

OFFICERS PRO TEM FOR 1945

President: Richard Rhems
Central High School, South Bend

Vice President: Richard Gumpper
Elkhart, Indiana

Secretary: Joyce Raih
Central High School, South Bend

Members of the Council: (Elected by Club Sponsors)
J. H. Otto (1943-1946); Prevo Whitaker (1944-1947);
Roy McKee (1945-1948); Darl Wood (1946-1949);
Ruth Wimmer (1945-1950)

* No meetings were held during the war period.

PROGRAM OF THE THIRTEENTH ANNUAL MEETING

BUTLER UNIVERSITY, OCTOBER 20, 1945

9:00 A.M., Jordan Hall

Exhibits, in the Zoology Laboratory, 9:00 to 10:00 A.M.

Papers, 10:00 A.M. to 12 M.

1. "Shades of the Future"—Phyllis Gouker, Senior High School, Elkhart
2. "Collecting and Mounting Insects"—Bill Kwolek, Lew Wallace High School, Gary
3. "Insects"—Edward Mockford and Dale Rice, Shortridge High School, Indianapolis
4. "Moths and Butterflies"—Dorothy Webb, Shortridge High School, Indianapolis
5. "The Model Airplane"—James McNair, Crispus Attucks High School, Indianapolis
6. "Chemiluminescence"—John Martin, Shortridge High School, Indianapolis

Business Session, and Continued Scientific Program, 1:00 to 3:30 P.M.

1. Colored Motion Pictures—Dr. Howard H. Vogel, Wabash College
   Birds of Indiana
   Hatching of Bobwhite Quail Eggs
   Natural History of Indiana—Emphasis placed on social behavior of local birds and mammals
2. "A Review of Atomic Transformation produced by Nuclear Bombardment"—Lloyd Hill, Technical High School
3. "Economic Importance of Some Common Birds"—Louis Wuellner, (Lantern), Technical High School, Indianapolis
4. "Back Tracing the Wisconsin Glacier"—Francis Weber, Shortridge High School
5. "Smaller Rodents of Indiana"—Steve Wainwright, Shortridge High School
6. Talk, M. M. Williams, Club Sponsor, Bloomington High School
   Report on the Progress of the Indiana Junior Academy of Science, by Dean Howard E. Enders, State Sponsor

MINUTES

The thirteenth annual meeting of the Indiana Junior Academy of Science was held Saturday, Ocober 20, 1945, in Room 131, Jordan Hall, Butler University, Indianapolis.

Dr. Howard E. Enders, State Sponsor of the Indiana Junior Academy and Dean of the School of Science, Purdue University, greeted the members of the Junior Academy and introduced the *pro tem* officers selected by the Council:

President, Richard Rehms, Central High School, South Bend, Indiana

Vice President, Richard Gumpper, Elkhart, Indiana

Secretary, Joyce Raih, Central High School, South Bend, Indiana

The president *pro tem* opened the meeting by calling for the minutes of the previous meeting. They were read and approved (none being held during the period of the war), with the suggestion by Dean Enders that the minutes of the two annual meetings of the Indianapolis section of clubs be embodied in the present minutes.

The first number on the program was given by Phyllis Gouker, Senior High School, Elkhart, Indiana, on "Shades of the Future." She gave a very interesting talk on the trees of the city of Elkhart, with excellent plans for the future, additions through the help of her science club. She illustrated her talk by means of charts to cover the main points in relation to the care of the trees that have been set out.

The president then introduced Bill Kwolek of Lew Wallace High School, Gary, who gave a very interesting talk on "Collecting and Mounting Insects." Dean Enders commended Bill and pointed out the good services the clubs of the Indiana Junior Academy of Science have rendered to its members and in this respect cited the outstanding progress made by another particular student. He urged all of us to follow through with our interests in science.

The president then called on Edward Mockford and Dale Rice, both of Shortridge High School. Edward began his talk by explaining the meaning of the word "insect" and told how insects are classified and given their names. He also explained the instruments used in collecting different kinds of insects. Dale Rice then took over and explained the classification of the orders of insects by means of a chart he drew on the blackboard.

"Moths and Butterflies" was the next topic, discussed by Dorothy Webb, of Shortridge High School. She explained how and why she became interested in moths and butterflies, and explained many interesting features by pointing them out on the species which she had mounted.

The fifth speaker of the morning was James McNair of Crispus Attucks High School who represented the CPA of Indianapolis. His talk was on the "Model Airplane." He showed us a very interesting model which he had made, and explained the parts, and principles of the model airplane.

The president introduced John Martin of Shortridge High School, who gave us a series of experiments on Chemiluminescence, in a completely darkened hall to which the group adjourned for this purpose. A series of very striking experiments lighted the dark hall through a range of colors and intensities.

The meeting adjourned for luncheon.

The afternoon session was held at 1:00 P.M., Jordan Hall. Miss Ruth Wimmer, Sponsor of the Phi Chem Club, Elmhurst High School, Fort Wayne, was elected to the Council by the councilors to succeed Mr. H. H. Michaud, former sponsor of the Nature Club, North Side High School, Fort Wayne. Election of officers for the next year was then held. Dean Enders read the list of nominees and the club members balloted for and elected the following officers for the year 1946:

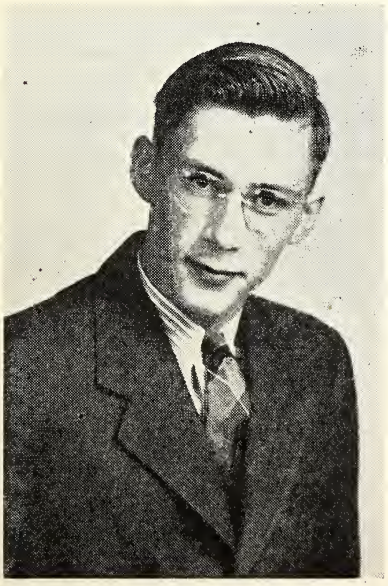
President: Charles Giffen, Phi Chem Club, Elmhurst High School, Fort Wayne

Vice President: Robert Reinhold, Central High School, South Bend

Secretary: Robert Lovett, Science Club, Mishawaka

The next part of the program was a series of motion pictures, in color, shown by Dr. Howard H. Vogel, Jr., Professor of Zoology at Wabash College, on birds and other animals in Indiana. Emphasis was placed on social behavior of local birds and mammals.

The president then introduced Lloyd Hill, who gave us a review of the atomic transformation by nuclear bombardment. He confined most



Bill Kwolek

Phyllis Gouker

of his talk to the neutrons of the atoms. He also explained the true meaning of radio activities of the elements.

The Council announced its choice of Phyllis Gouker of Elkhart, and Bill Kwolek of Gary, as the "Best Girl" and "Best Boy," respectively, to recommend for Honorary Membership in the American Association for the Advancement of Science.

The president then introduced Louis Wuellner, of Technical High School, who talked on "The Economic Importance of Some Common Birds." He showed pictures, by lantern, and pointed out their main characteristics of the different birds shown.

Francis Huber, Shortridge High School, talked on "Back Tracing the Wisconsin Glacier." He flashed the map of the middle western states and traced the route of the glacier.

The president introduced Steve Wainwright of Shortridge High School, who talked on "Smaller Rodents of Indiana." He told of the characteristics of the white-footed mouse, field mouse, buff-breasted mouse, leming mouse, pine mouse and the jumping mouse.

The sponsor, Mr. M. M. Williams, of the Bloomington High School, told how the members of his club developed a record of high achievement and advised us to plan our projects with our sponsor.

Dean Enders told us of the origin of the Indiana Junior Academy of Science and of the many benefits we can gain by being members. He told us that fifty-four clubs belong to the Junior Academy. Suggestions were made to keep in touch with other clubs, by means of some kind of Round Robin letter of communication between the several clubs.

The meeting was adjourned at 3:30 P.M.

JOYCE RAIH, *Secretary Pro Tem*,
Central High School, South Bend.

MEMBER CLUBS

INDIANA JUNIOR ACADEMY OF SCIENCE

Town	*Name and School*	*Date Organized*	*Sponsor*
Anderson	Science	1936	M. J. Brozier
Bedford	Phi Pi Chi	1941	W. D. Prather
Bloomington	*General Science, Jr. H. S.	1931	M. M. Williams
	University School-Science	1938	W. B. Miner
Cambridge City	Tri Science	1934	J. L. Bozarth
Crawfordsville	*Audubon Society, Jr. H. S.	1931	Emmet Stout
East Chicago	Edison Club, Roosevelt H. S. (Inactive)	1935	Harry Apostle
Elkhart	Junior Academy		N. E. Adams, Evelyn Wagoner
Fort Wayne	*Geography Council, North Side H.S.	1932	
	Nature Club, North Side H. S.	1936	Vesta Thompson
	Jr. Academy Club, Franklin H. S.	1945	Wm. A. Willer
	Phi Chem Club, North Side H. S.	1937	H. A. Thomas
	Phy Chem Club, Elmhurst H. S.	1935	Ruth Wimmer, Ralph Young
	Nature Club, Central H. S.		Iva Spangler
Gary	Biology Club, Lew Wallace H. S.	1935	Lola Lemon
	Klub Kem Club, Lew Wallace H. S.		Mrs. Helen Mackenzie
	Biology Club, Wm. A. Wirt School	1945	Mrs. Frances Huddleston
	T Square Club, Tolleston H. S.	1944	Olive Leskow
Gas City	Science Club	1936	Roy McKee
Greencastle	Science Club	1936	F. N. Jones
Guilford	Science Club	1936	L. B. Willis
Hammond	Edison Acad. of Science, Edison School	1938	
Indianapolis	*Crispus Attucks H. S.—Biology, Chemistry, Zoology and Radio	1931	Mrs. Kuykendall, A. C. Cox, G. W. Wade, L. C. Parker
	George Washington H. S. Science Club	1937	J. H. Otto
	*Technical School—Nature Study Club	1932	C. F. Cox
	*Technical School—Physics Club		Chas. Brosey
	Technical School—Chemistry Club	1942	Mr. Bolander
	*Shortridge H. S.—Chem. Club	1931	Wm. Johnson, Messrs. Wade, Block,
Lafayette	Biology Club, Jefferson H. S.	1939	Miss Wilson
Lawrenceburg	Phi-Bi-Chem	1939	H. P. Harrison
Lowell	Science Club	1935	C. N. Seeright
Madison	Science Club	1938	Evans Cottman
Marion	Science Club	1936	Pauline Mayhug, L. L. Strickland

Town	*Name and School*	*Date Organized*	*Sponsor*
Mishawaka	Science Club	1936	Darl F. Wood
Montmorenci	Jr. Academy of Science	1933	
Mooresville	Science Club	1936	Fitzhugh Lee
Muncie	Science Club, Jr. H. S. (Blaine)	1934	J. D. Young
New Albany	Jr. Academy of Science, Jr. H.S.	1935	Gladys Knott
North Madison	*Hilltop Nature Study Club	1931	V. Shoemaker
N. Terre Haute	Otter Creek Jr. Acad. of Sci.	1939	Prevo Whitaker
Paoli	Science Club	1935	
South Bend	Central H. S.	1939	
	Central Junior Academy		V. C. Cripe
(a)	Junior Izaak Walton Club		A. L. Smith
(b)	Chemistry Club		F. S. Sanford
(c)	Junior Audubon Club		Arthur L. Smith
Sullivan	Camera Club		Ruth Hinkle
Terre Haute	Jr. Science Club (Laboratory School)	1939	G. Shontz
	State Discovery Club, Sr. H. S.	1939	W. Woodrow
	Laboratory School		V. C. O'Leary
Tipton	Nature Club	1935	W. D. Hiatt
Valparaiso	*Sciemus Club	1931	C. O. Pauley
Wabash	Science Club	1936	R. D. Black
W. Lafayette	Biology Club	1933	Anna Inskeep

* Charter Clubs.

NECROLOGY

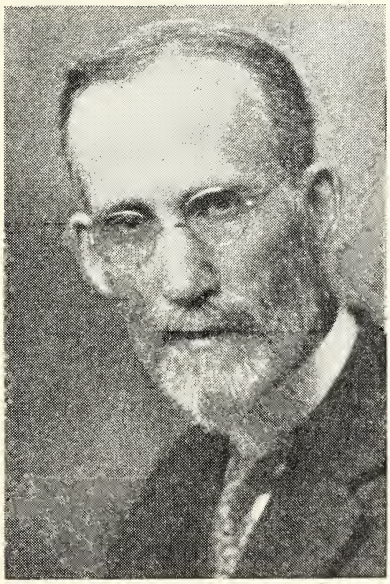
Will E. Edington, DePauw University

Henry Lane Bruner

Knox County, Illinois
January 10, 1861

Indianapolis, Indiana
March 17, 1945

When Henry Lane Bruner came to Butler University in 1892 as Professor of Geology and Biology he came at a time when Indiana was losing many of its finest scientists. David Starr Jordan had just gone to Stanford University the preceding year, taking with him John C. Branner, Joseph Swain, Oliver P. Jenkins, and others. Barton W. Ever-



mann had just left to become chief of the United State Bureau of Fisheries, and John M. Coulter had completed one year as President of Indiana University and was to leave the State the next year to accept the presidency of Lake Forest University. Both Jordan and Evermann had held positions at Butler University. Jordan was succeeded at Butler in 1879 by Oliver P. Hay, who had been Bruner's teacher at Abingdon College, and when Hay resigned in 1892 because of differences of opinion

with the college authorities on the theory of evolution, he was succeeded by his old pupil, Bruner. So Henry Lane Bruner came to Butler in an atmosphere charged with controversy. Also he immediately came into contact with that fine group of scientists, W. S. Blatchley, Amos W. Butler, Stanley Coulter, Carl H. Eigenmann, J. C. Arthur, W. A. Noyes and David W. Mottier, all enthusiastic members of the Indiana Academy of Science. Dr. Bruner joined the Academy in 1892, and at the time of his death he was the oldest active member in the Academy, both in age and years of membership.

Henry Lane Bruner was born of pioneer parents in Knox County, Illinois, on January 10, 1861. After completing the work of the public schools he entered Abingdon College, now known as Eureka College, from which he was graduated in 1880. He spent the next year in graduate study at Yale University and then returned to Abingdon College as Professor of Natural Science where he remained for five years. During that time he spent his summers at Woods Hole, Massachusetts, as Assistant United States Fish Commissioner. After leaving Abingdon, he held a similar position at Drake University before coming to Butler in 1892 as Professor of Biology. Several years later he went to Germany where he studied under the great comparative anatomist, Wiedersheim, at the University of Freiburg and received the Ph.D. degree in 1896. He was Harrison Fellow at the University of Pennsylvania during 1910-1911. He lectured before the Indiana Dental College from 1913 to 1917, and was on the summer staff at Indiana University in 1920. With the reorganization of the Natural Science Department at Butler in 1919, Dr. Bruner was made Professor and Head of the Department of Zoology, which position he held until his retirement in 1938 as Emeritus Professor of Zoology. He was also Director of Graduate Studies at Butler from 1932 until his retirement.

Dr. Bruner was active in Academy affairs. He was editor of the *Proceedings* for 1909 and 1910. At the meeting of the Executive Committee in 1916 he spoke on the matter of establishing an Academy Research Foundation, and he was appointed chairman of a committee to make a report the following year. Favorable action was finally taken in 1919, following a revised report by Dr. Bruner, R. W. McBride and John S. Wright, and Dr. Bruner was appointed one of the six Directors of Research for 1920. The Academy elected him as its President in 1920. In his Presidential Address on "Biological Laws and Social Progress," he deplored man's violation of the laws of progressive evolution. He was a member of the Academy State Library Committee from 1931 to 1933, and of the Committee for Bonding Trustees from 1932 until ill health forced him to resign ten years later.

Dr. Bruner occasionally presented papers before the Academy but his primary interest was in teaching. He was the author of seven published papers on comparative anatomy, embryology and physiology, and of a college textbook, "Laboratory Directions in College Zoology," which has passed through three editions.

He was a Fellow of the American Association for the Advancement of Science and of the Indiana Academy of Science. He was also a mem-

ber of the Society of Zoologists, the Eugenics Society, and the Iowa and New York Academies of Science.

Dr. Bruner faithfully served Butler University forty-six years as an active worker and in grateful acknowledgment that University conferred the Sc.D. degree on him in 1932. The Academy honored him in 1944 as one of its Fifty-Year Members. He will be long remembered as a fine, dignified, scholarly gentleman whose influence was ever wielded for the betterment of mankind. Never officious, but always kindly, he represented the best in science and human relationships.

CLARENCE EDMUND EDMONDSON

Ellettsville, Indiana — South Pasadena, California
April 9, 1883 — December 15, 1944

College administration has become so complex during the past quarter of this century that most of the work of administration formerly done by the Faculty is now done by deans of one kind or another. Much of the social relationships, not covered by tradition, is controlled by Deans of Men and Deans of Women, and often these deans are more intimately known to the students and alumni, and more widely known to the public at large, than the administrative heads. To be a successful Dean of Men requires a fine personality, a high degree of intellectual integrity, and a genuine understanding of and sympathy with student problems, as well as outstanding ability to influence and control student sentiment and social relationships. Dean Clarence E. Edmondson had all these qualities and for twenty-five years was known as the friend and confidant of Indiana University students. Affectionately known as "Pat," his retirement at Indiana University in 1944 was received with keen regret by Faculty, students and alumni alike.

Dean Edmondson spent almost his whole life in Indiana. Born at Ellettsville, April 9, 1883, just seven miles from Bloomington, he received the usual public school education and then entered Indiana University, graduating in 1906. He spent the next three years teaching in Crawfordsville High School. Returning to Indiana University in 1909 as a graduate assistant in physiology, he received the A.M. degree in 1912, and was immediately made an instructor, which rank he held for four years. In this period he completed the work for the doctorate and received his Ph.D. degree in 1914. He was promoted to assistant professor in 1916, and in 1919 was made Associate Professor of Hygiene in the Medical School and appointed Dean of Men. He received the rank of professor in 1925, and was made Head of the Department of Hygiene. He continued his work in both capacities until he was granted a leave of absence in 1943, and finally retired in July, 1944. He and Mrs. Edmondson, who was also a member of the Faculty of Indiana University, went to South Pasadena, California, where he passed away on December 15, 1944.

Early in his career Dean Edmondson had some time for research and he published several papers on the physiology of the thyroid and

thymus glands. He joined the Academy of Science in 1912 and continued his membership to the end. He was a Fellow in the American Association for the Advancement of Science, a member of both Phi Beta Kappa and Sigma Xi, and also of the Mayflower Society. He served as President of National Association of Deans of Men in 1932.

He was a man of broad interests. He was scoutmaster of one of the first troops of Boy Scouts organized in Bloomington. A master of billiards he could hold his own with all comers, students and Faculty alike, and he won the national Faculty straight-rail billiards championship of the United States in 1936 and held it until 1944. He was an excellent shot and spent much of his spare time hunting and trapshooting.

Dean Edmondson was an excellent teacher and administrator. His lectures were characterized by clarity, sincerity and absolute honesty. Firm but just in dealing with students he had their confidence and respect because they knew he had the student slant on student problems. Known and loved by thousands of students and alumni of Indiana University as a friend and adviser, his memory will long be cherished.

ARTHUR LEE FOLEY

Hancock County, Indiana — Tampa, Florida
February 22, 1867 — February 13, 1945

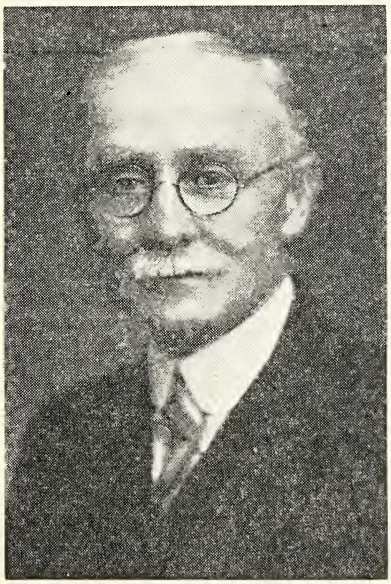
When death claimed Arthur Lee Foley, on February 13, 1945, the Indiana Academy of Science lost one of its most loyal, prominent and influential members, and Indiana University lost another of its few remaining distinguished Faculty members whose careers in science extend back to the time of the presidency of David Starr Jordan. Although Dr. Foley retired from teaching in 1938 with the title of Emeritus Professor of Physics, he nevertheless remained vigorous and active until the day of his death which occurred two weeks after he and Mrs. Foley had gone to Tampa, Florida, to visit his sister.

Arthur Lee Foley was born in Blue River Township in Hancock County, and in his later years he regularly returned to this township where he owned a farm and where he was finally laid to rest. As a child he attended the country schools, and at the age of fifteen he entered Central Normal College at Danville where he spent two years in study. He began his teaching in 1884 in the public schools of Vivalia. The following year he was married and returned to his home county as principal of the Cleveland school. Two years later he took a position in the Johnsonville, Illinois, public schools and remained one year. In 1888 the Foleys went to Bloomington where young Foley entered Indiana University. Two years later, after receiving the A.B. degree, he was appointed an instructor of physics which position he held for one year while he worked for the Master's degree which he received in 1891. He was immediately appointed Associate Professor of Physics which rank he held until 1897 when, at the age of thirty, he was made Professor and Head of the Department of Physics. During his tenure as associate

professor he did graduate study in 1894 at the University of Chicago, and later entered Cornell University as a Fellow where the Ph.D. degree was conferred on him in 1897. He went to Europe in 1908 and studied at the University of Berlin. At the time of his retirement in 1938 he had completed fifty years of intimate association with Indiana University, forty-one years of this as Head of the Department of Physics.

Dr. Foley was a man of tremendous energy who had little patience with superficiality and sham, and he was sharp and outspoken in his denunciation of all such. But in his personal relationships he was most genial and charming. He was at his best in the class room and his lectures were illustrated very completely and the subject matter was presented in a most interesting way.

He enjoyed a national reputation as a physicist, being starred in *American Men of Science*. At Indiana University he was Waterman



Research Professor from 1917 to 1925. During this same period he was Director of Research for Affiliated Colleges of Indiana. He was chairman of the research committee of the Indiana State Council of Defense from 1915 to 1918, and Director of the United States Radio School at Indiana University in 1918. He was also a member of the Acoustical Committee of the National Research Council from 1919 to 1921.

Dr. Foley joined the Indiana Academy of Science in 1894 and was made a Fellow in 1897. He edited the *Proceedings* in 1907, was twice vice-president, in 1908 and 1914, and was chairman of the Academy Research Committee from 1924 until the time of his death. He was President of the Academy in 1909 and presided at the Twenty-fifth An-

niversary meetings of the Academy which were attended by a large number of the greatest scientists at that time in the United States. Dr. Foley's presidential address was entitled "Recent Progress in Physics," and other speakers on the program with him were Harvey W. Wiley, John M. Coulter and David Starr Jordan. In the sectional meetings papers were given by H. A. Huston, B. W. Evermann, Charles W. Greene, C. A. Waldo, Severance Burrage, W. A. Noyes, A. H. Purdue, J. Rollin Slonaker, D. T. MacDougall, J. C. Arthur, Frank D. Kern, Katherine Golden Bitting, Mel T. Cook, O. P. Hay, C. H. Eigenmann and Charles C. Deam. In his address it is worth noting, in the light of the recent atom splitting discoveries, these prophetic words which show Dr. Foley's deep insight. After discussing the discoveries and theories of the molecular structure of matter, the electrical nature of matter, and the dependance of mass upon velocity, Dr. Foley went on to say: "Certain it is we are face to face with energies of which no one even dreamed a few years ago. Whether we call this energy intra-atomic, sub-atomic, inter-elemental or some other name, we know certainly that it exists, and that it exists in quantities far beyond the power of man's mind to comprehend. Man hopes some day, somewhere, somehow, to discover the means of unlocking this infinite storehouse. If this discovery is ever made, all the others which man has made will pale into insignificance beside it." Thus Dr. Foley spoke thirty-six years ago.

It was not uncommon for Dr. Foley to present three or four papers and notes at an Academy meeting. He was the author of some ninety published papers. His principal research was in the field of acoustics, but his interests covered the whole field of physics, subjects of his papers ranging from "Tenacity of Gelatine," "Synchronous Leaping of Fish," "Four Wheel Brakes," to "Rockets or Rackets" and "After the War 'Transportation.'" He was the inventor of numerous acoustical and mechanical devices and he served as a consulting acoustic engineer for radio and phonograph companies and manufacturers of sound absorbing materials. His classic experiments on locomotive whistles were dramatized by the University of Chicago in "Human Adventure" some years ago, and resulted in an improvement in the location and design of locomotive whistles. He wrote a textbook "College Physics" which has been used by over three hundred colleges and has passed into the fourth edition. Thousands of copies of it were used in the United States Army training programs.

Dr. Foley was a Fellow of the American Association for the Advancement of Science, and he held memberships in the American Physical Society, Acoustical Society of America, American Association of Physics Teachers, Sigma Xi and Phi Beta Kappa.

Central Normal College honored him in 1941 with the degree of Litt.D., and at the 1944 meeting of the Indiana Academy of Science special honor was paid to him as one of the three living active fifty-year members. Dr. Foley seldom missed a meeting of the Academy and in his later years he was nearly always accompanied by Mrs. Foley.

Certainly the State of Indiana owes much to Dr. Foley who served the youth of the state so well. With his passing the Academy has lost

another tie with the days when Indiana was noted for its scientists. He has gone to join the "Giants of Those Days."

CLARENCE O. WARNOCK

Indianapolis, Indiana
February 25, 1886

Indianapolis, Indiana
December 13, 1943

Clarence O. Warnock was a most successful business man who pursued science as a hobby. A citizen of Indianapolis all his life, he graduated from Manual Training High School, and became an apprentice in electrical work. Later he traveled for a while as a representative for two theatrical firms. However, being interested in automobiles, he began his automotive career as a toolmaker, after having spent several years in the experimental department of the Marietta Glass Company. He worked for various individuals and companies before organizing his own company in 1917, which became the C. O. Warnock Company, one of the oldest Ford dealers in Indiana. He was much interested in the 500-mile Speedway Races and at one time worked for Ray Harroun, a one time winner of the race.

However, after he had firmly established his company and had more leisure time he became interested in postage stamps and Mexican archaeology as hobbies. In all he made almost thirty trips to Mexico to study the ruins there. He became an authority on Mexican archaeology and at the time of his death he owned a very valuable collection of Mexican relics and pottery. He had many friends in Mexico and had just returned from a trip there three weeks before he passed away from a heart attack.

Mr. Warnock was one of the leading automobile dealers in Indianapolis and a public spirited citizen. He had served for five years as president of the Indianapolis Automobile Trade Association, and he was active in the National Automobile Dealers Association, The Indianapolis Chamber of Commerce, and the Better Business Bureau. He was a 32nd degree Mason and a member of the Shrine. He belonged to the Indianapolis Stamp Club. He joined the Indiana Historical Society in 1929 and became a member of the Indiana Academy of Science in 1935.

The Academy has need of more members from the business world, men and women who have the leisure time and enthusiasm to study some phase of science as a hobby. Such hobbies should be encouraged, for men like Mr. Warnock have made and can make a distinct contribution to scientific advancement. It is to be sincerely regretted that Mr. Warnock was called away when his service to science and the Academy could have been so effective.

PRESIDENTIAL ADDRESS

Biology and the Post-War World

MILLARD S. MARKLE, Earlham College

The world looks confidently to all the fields of science to create in the post-war period a bright new world, replete with new comforts and conveniences. Some of these innovations the layman definitely envisions; others he vaguely comprehends and still others he cannot describe, but he is sure that science can provide them, though the methods are as little understood as if the work were done with a magic wand. New foods, new gadgets fulfill too often his conception of the abundant life.

Biological science will undoubtedly proceed to develop, along with the other sciences, many lines of progress already well begun. We may expect that the methods used in the spectacular development of hybrid corn will be employed in securing better yields and quality of many domestic crops. Explorers will continue to bring in many foreign plants to supplement the ones we now raise. More rapid transportation by plane will bring to northern tables many new and delectable tropical foods now little or not at all known. New woods and fibers will be used. The further development of animal breeding will provide more efficient production of meat and other animal products. The increased use of plastics and other products of organic origin will encourage the production of new crops in the temperate zone and will turn the attention of northern nations to the tropics, where plant crops grow throughout the year.

The complex developments in the field of health will continue. New antibiotic substances may exceed penicillin in effectiveness; new chemotherapeutic drugs may surpass the sulfa-compounds. A better understanding of tropical diseases, through an increased knowledge of parasitology, will increase the safety of travel and vastly improve the social and economic status of tropical peoples.

But, however bright the new world may appear on superficial thought, and however diligent technical scientists may be, thinking persons all over the world view the future with misgiving, even dread.

Harold Fey recently said[1], "We are the most saddened, bewildered and frightened victors in the history of the world. If Concord's shot was heard round the world, the blast at Hiroshima has shaken a ghost in every closet."

With what satisfaction can we anticipate a world as a habitation for future generations if recurring and ever more destructive wars blast the material and cultural accumulation of the ages and the idealism of social and national groups and mark for their victims the finest individuals of each generation?

1. Christian Century, Sept. 26, 1945.

No sooner had the atomic bomb been used than a clamor ensued to have it outlawed. Even the scientists who developed it are asking that it be put under international control. Some justify its use as a means of making unnecessary the invasion of Japan, thus saving many American lives. Others claim that Japan had already been defeated and that surrender must soon have come. So perhaps it had no justification, even on the basis of military expediency. It is a two-edged sword. Its secret cannot long be kept. With robot planes and atomic bombs, even our interior cities are wide open to attack, by an enemy anywhere in the world. Since more than ever before the advantage will come to the nation that strikes first, each must be fully prepared and constantly on the alert.

In a recent conversation, a scientist connected with the development of the atomic bomb is said to have remarked, "I am sorry it worked." A military man replied, "Amen."

Speakers and writers everywhere are urging the necessity of moving as rapidly as possible toward a fuller international organization than Bretton Woods, Dumbarton Oaks or San Francisco have provided. Wendell Willkie wrote of "One World." Freda Kirchwey heads a recent magazine article "One World or None."

Until the modern period, national and racial groups were separated by natural boundaries. Even as late as 1904, Russia and Japan could wage a war without its spreading beyond eastern Asia. A generation ago, Jules Verne's "Around the World in Eighty Days" was read with amusement; now a routine flight around the world is made in eight days.

Early wars were fought with primitive weapons—bare fists, then stones and clubs, then bows and arrows. Gunpowder revolutionized warfare and made coats of mail antique. Guns of longer range, explosives of greater power, airplanes of greater range and speed add constantly to the destructiveness of war. Now we have leaped at one bound into a new era with the atomic bomb. Some say that it has made war so terrible that mankind will shrink back in horror and wars will cease. But so it was said of the airplane and no doubt of gunpowder. But horror and dread do not deter men from war; and even though we fear that another war will destroy an already tottering civilization, we are preparing for future war.

There has been a great deal of thought in regard to the causes of war, but I believe that much of the philosophy that has supported modern war has its origin in biological thought. No concept has influenced more profoundly the thinking of the past century than that of evolution. Darwin's explanation of the origin of new forms of life was so thoroughly accepted that even though biologists have since repudiated much of it, as Darwin himself undoubtedly would have done, the man in the street is unknowingly a Darwinian. Darwin believed that changes sufficiently great to constitute a new species came about through the slow accumulation, often over a long period of time, of slight variations, preserved as the result of a struggle for existence, largely *within* the species. The Germans were especially committed to Darwinism. Some of their philosophers sought to justify war and the

creed of Nordic superiority by identifying war with the struggle for existence. Logically it became the duty of a superior race to impose its culture and philosophy upon other and inferior peoples. While in general we condemn this philosophy, we have been influenced by it to a greater extent than we are willing to admit. In the minds of the most of us, the world of life, including human life, is envisioned as "red in tooth and claw." Competition as a controlling force in life has come to be regarded as almost sacred and to be preserved at all costs.

So thoroughly have we accepted the idea of the necessity of competition that we have tended to lose sight of the fact than Darwin stressed the cooperative relationships existing between many forms of life, not only within species, but between species often genetically unrelated. Since Darwin's time, many more of these relationships have come to light. If we could analyze thoroughly any community of organisms, we would probably find as much cooperation as competition. The relation of mutual helpfulness, often called symbiosis, has many well-known examples, such as those existing between flowering plants and their pollinating insects; between the termite and its wood-digesting protozoa; between nitrogen-fixing bacteria and the legumious plants; between animals and the plants whose seeds they scatter.

These are obvious and direct relationships. Others may be less direct and more difficult to analyze. The soil contains a complex of organisms, influencing one another, as well as the plants whose roots penetrate the soil. The individuals of any community, such as a forest, are bound together by an intricate network of interrelationships, so that the community really becomes an organism. In a climax community, cooperation and competition are so balanced that the community may remain stable for ages.

Also, as Kropotkin[2] has pointed out, the bitterest phases of the struggle for existence are those involving the external inorganic environment. Drowning, freezing, starvation probably account for the major part of the deaths among lower organisms.

About the beginning of the present century, another natural-selection theory, the mutation-theory of DeVries, claimed the attention of scientists. DeVries showed that new species are formed not by the slow accumulation of recurring fluctuating variations, but suddenly, through the occurrence of mutations—new species, fully formed in one generation. The struggle for existence which ensues is a competition between the old species and the new. It is interspecific, not intraspecific. Within a species, the relationship of the individuals is cooperative, rather than competitive. In some groups of insects, as Wheeler and others have shown, cooperation is carried to the extreme.

Man is the only species of animal that spends a considerable portion of its energy in killing other members of the species. The chickens of a flock all peck and often kill the weakest member; pigs pursue and often destroy the "runts" of the herd; but this may serve to strengthen the hereditary quality of the group through the elimination

2. Kropotkin, P., *Mutual Aid, a Factor in Evolution.*

of the weak. But instances where members of a species array themselves in organized combat with others of the same species are rare. Man alone indulges in war.

It is not difficult to show that war does not accomplish the goal of the struggle for existence; that is, the survival of the fittest. In war, the bravest and most indealistic volunteer; the best, physically and mentally, are drafted. On the average, the weakest are reserved to propagate the next generation. The progressive deterioration of nations such as France, after a long succession of wars, has been demonstrated.

To summarize: I have tried in the folllowing ways to show that biology does not justify war:

1. Darwin emphasized cooperation as well as competition. Since Darwin's time the role of cooperation as a life-force has come to be more fully understood.

2. As Kropotkin early showed, the keenest phases of the struggle for existence are those involving a struggle with the external environment.

3. DeVries, in his mutation-theory showed that the fate of a species depends upon a struggle between species, rather than within a species.

4. War does not conform to the test for the struggle for existence, since it preserves the unfit, rather than the fit.

The role of cooperation (mutual aid) as a biological factor was discussed in 1880 by Kessler, the Russian zoologist, and greatly expanded in 1902 by Kropotkin[2]. Allee and his students have carried on an elabor- the program of research, seeking to analyze the interrelationships existing among aggregations of animals. They have shown the advantages that come to animals living in groups, rather than singly; the effects of overcrowding in large aggregations; the various orders of dominance and subordination that come to exist in an animal group. They believe that a social organization involving cooperation was not an emergence late in the evolutionary process, but a principle of life that has existed from the beginning. It is conceived that the initial establishment of life on the earth was successful only when a sufficient number of individuals appeared simultaneously to permit the operation of the principle of cooperation. It is their belief that the interrelationships existing among groups of men are not merely analogous to those among lower animals, but that they have actually developed from them.

In man the element of purposiveness often modifies his interrelationships in extent, direction or definiteness of goal. It is the existence of this element of purposiveness that has given rise to the hope that groups of men, properly informed and motivated, may gradually bring about a balance betwen the competitive and the cooperative elements within the group and that this balance may eventually spread throughout the whole of human society. In small groups a high degree of balance has often been attained. Kropotkin points out the harmony existing within primitive tribes. Small civilized communities are often quite harmonious. Switzerland, with its traditionally antagonistic German, French and Italian elements, has been a peaceful and successful nation. Small cooperative communities, such as New Harmony, have had many elements

of success. A modern organization successfully employing cooperation as a dynamic force in community life is the Cooperative Movement, beginning among some poor weavers in Rochdale, England, in 1844, and spreading through other countries, including the United States, but especially successful in the highly intelligent Scandinavian countries, where, attempting to supplement, rather than to displace the existing capitalistic system, it has remade the economic life of those countries.

But now we are beginning to wonder if we can depend upon this slow evolutionary process for the successful establishment of the principle of cooperation. The time-element has suddenly assumed such an importance that if war is to be overcome before civilization is destroyed, all the forces that tend to integrate human society, rather than to disintegrate it, must be mobilized. As D. Elton Trueblood says in "The Predicament of Modern Man," "We are engaged in a race with Catastrophe."

Unfortunately the sciences most effective in providing the machines for waging war are those that are most exact—that is, involving the greatest use of mathematics and embodying a great fund of exact knowledge; while those that must be employed if the cause and cure of war are to be discovered are least exact and have principles least understood, especially as they apply to larger social and political groups. The accuracy and efficiency of the engines of war have reached a development undreamed of a generation ago; but the causes of war are rooted in the minds and spirits of men and in deep-seated traditions of national and racial groups. Sociology, economics and political science, while calling themselves "sciences" are less exact than the least "scientific" of the natural sciences. Psychology is far from being an exact science, though it has made great progress. Religion, which should be a potent force, is too often dominated by superstition, tradition and dogma.

In earlier times war was accepted as a legitimate procedure for the attainment of national goals. Recently nearly all the civilized nations solemnly renounced war as an instrument of national policy; but this was followed by the worst war in history. National leaders, actuated by motives of political expediency, personal or national ambition, plunge the world into war, with no thought of seeking the counsel of experts in the social sciences, to say nothing of using the results of research in the natural sciences.

Dr. Lyman Chalkley, of the Office of Scientific Research and Development, in a recent article in *Science*[3] points out that "Although this (World War II) was a scientific war, neither scientists nor technologists were members of the top military or civil policy-making groups." If the decisions on public affairs were based upon painstaking scientific research, rather than prejudice, tradition or political expediency, political crises leading to war would often be avoided.

The indifference to science on the part of our federal government is exemplified in its attitude toward scientific conventions. Meetings em-

3. Chalkley, Lyman, Science, Technology and Public Policy; Science, **102**, No. 2647, Sept. 21, 1945.

phasizing entertainment, such as horse-races or athletic events secured ready permission to meet; but grave consideration was necessary before the Indiana Academy of Science was given such permission. Of the major powers, Russia seems to be supporting scientific research most heartily. Even during the war, when Russia was very hard-pressed, an elaborate program of research continued.

If biology has provided the key to the solution of interracial and international conflicts through the principle of cooperation, it is evident that the next step is the practical application of this prinicple to the present world-crisis. This will require the mobilization of the best philosophical and scientific thought. The development of the atomic bomb cost two and one-half billion dollars and the coordinated efforts of sixty-five thousand scientists and technicians, over a period of years. The elimination of war is a goal as full of promise for the future of mankind as any toward which he can strive. Shall we entrust the future of the race to politicians to whom diplomatic procedure, military strategy, political expedience or national aggrandizement are too often the bases of decision, or shall we pool the abilities of our best minds? Clemenceau said that war is too important a matter to be entrusted to soldiers. Similarly, international affairs are too important to be entrusted to politicians.

Some will say that the establishment of world unity is simple, that all that is needed is to implant in the hearts of men the principles of Christianity. But just what does this mean in this complicated modern world? Christians seem confused. Christian Americans have bombed Christian Germans. Obliterated Nagasaki was the center of Christianity in Japan. Some go to war believing that they are thereby advancing the cause of Christianity; others refuse for the sake of conscience.

We have made great progress in working out our individual relations to other individuals. Property rights are better established. Dueling is no longer respectable. Fundamental individual rights are guaranteed by law. But suddenly through the development of means of transportation and communication, we have been brought into direct contact with other races and nations. The principles that seemed to work in the old world of isolation do not seem to operate or we do not know how to apply them in the new and more complex situations. The world has suddenly become a neighborhood. We shall need all the wisdom we can get if it is to become a brotherhood. If the principle of cooperation is fundamental, how can it be applied on a world scale? Is war a human instinct so deep-rooted that it cannot be eliminated? Is there a "moral equivalent of war"? Can human nature be changed, or are we so bound by inherited tendencies that we are incapable of unity on a world-wide scale? What shall we do with atomic power? What kind of an educational system will fit men to live in the new world? How much autonomy must each nation relinquish in order to form a world-state? What shall be done about tariffs? What are the aims of human society. In short, what is worthy of our faith?

A recent editorial in the *New Republic* reads: "It is high time for us to concentrate our attention and our ingenuity on achieving as penetrating, as accurate, as cool and competent a body of knowledge about

how to choose our aims and how to effectuate them as we have hitherto devoted to the secrets of matter." Also, "Scientists are better trained to cooperate with one another on an international level than any other group."

Tennyson says in Locksley Hall, "Science moves but slowly, slowly, creeping on from point to point." But in the development of the atomic bomb, science moved with a speed and certainty that surprised even those who participated.

Science does not claim to be able alone to remake the world; but it does claim to have a unique method of searching for the truth, which, if used cooperatively by all constructive agencies, may yet prevent civilization from sinking into a new Dark Age. A "holiday for science" has been proposed, to allow other agencies to "catch up" with the progress of scientific technology; but what we need is not less science, but the application of the scientific method to the study of all human problems.

ANTHROPOLOGY

Chairman: J. C. HOUSEHOLDER, Indianapolis

Mr. Wm. B. Adams was elected chairman of the section for 1946.

The distribution of aboriginal bastioned stockades in North America. MARY FRANCES KELLY, Indiana University.—Certain of the pre-Columbian Indians had a very highly developed system of defensive warfare. One of the most important manifestations of this system was the bastion. A bastion is a walled outset from a fortification, placed in such a position that the defenders can keep up a cross-fire along the front of the main wall. It is easy to see of how much value a system of bastions at convenient bow-fire from each other would be to a fortification.

There appear to have been three main developments of the bastioned stockade. Several Algonkian and Iroquoian villages have been found to include bastioned stockades, and the Mandan and Hidatsa of the Upper Missouri River also included the bastion in their scheme of warfare. But we must look to the Southeastern Area before we find wide and concentrated distribution of the bastion.

This southeastern development appears to center in the state of Tennessee along the great river valleys. From there it extends as far north as Aztalan in Wisconsin, and the eastern and western limits are provided by those Algonkian, Iroquoian, and Mandan-Hidatsa bastions that I have mentioned before. The sites where bastions are found in the Southeastern States are predominately Middle Mississippian in culture development.

A Preliminary Report on Martin County

William Richard Adams

At the present time under the employment of the Indiana Historical Bureau and the direction of Mr. Glenn Black, an archaeological survey is being made in Martin County. Since there is probability of dam construction which will flood White River Valley between Shoals and Williams, special attention has been given to this pool area.

White River is located in a deep meandering valley into which the larger tributary streams flow in flat valleys. The minor ravines descend from the irregular ridge-tops as steep U-shaped trenches in which bed rock is prominent. The flat valleys contrast with their steep rocky sides where vertical bluffs of massive sandstone are prevalent. Bluffs of from twenty to fifty feet are common and vertical ones one hundred feet or more in height occur. On the outsides of the meander curves of White River these bluffs are particularly prominent and precipitous.

The two northern townships of Martin County are closed to examination since they are within the Naval Ammunition Depot, although from reports of former inhabitants there is little of archaeological interest there. Lost River township in the southeast has several good sites in it, although work there is hampered by the roughness of the land. Little work has been done so far in the most southwestern township, but I think it will likely yield some very interesting sites. In the central five townships are located the majority of the 130 Martin County sites found thus far.

For the county in general, six shell mounds have been located while reports of three more are on hand. These range from forty to one hundred and fifty feet in diameter, and are on high bluffs, with two exceptions. One is located at the foot of a vertical cliff and may represent material thrown over from a hill-top camp, since I have a report of shells having been seen on top of this cliff. The other is on a low sand ridge extending into the old river bottom.

I have visited about half of the twenty-seven overhangs or rock shelters reported. Four overhangs yielded small quantities of pottery, three have hominy holes, and three show no indication of use.

Fourteen locations have been designated as village sites—either on the basis of pottery presence or quantity of material found. One site within the pool area is of special interest and might be worthy of exploration. Here White River in flooding has produced a washout close to the edge of a level tract of several acres, most of which would probably show habitation debris if tests were made. This is in pasture now and the owner prohibits digging. Many pottery sherds are found there mixed with quantities of every fine flint chips and animal bones. The artifacts found by the survey consisted mainly of about a dozen finely-made trianguloids and a small expanded base drill less than an inch long.

One other village of some size is located in the southern end of Martin County. It is situated on a flat-topped ridge a quarter mile

from White River and is perhaps one hundred feet above the river. This site is approximately three hundred yards long by one hundred yards wide. Contained in this area, more or less at the edge, are three or four concentrations where shell, bone, flint, and fire-cracked rock are in abundance, and which I think constitute refuse pits. No pottery has been found at this site, although for surface material this is one of the richest sites in the county.

With the exception of possibly one small earthen and one or two stone mounds, all reports of mounds in Martin County have been unproductive.

Several burial grounds have been reported, but only one offers any evidence. This is located at one end of a half-mile length of river bottom which shows continuous traces of occupation, and which is supposed to have been a favorite camping site during historic times. Here the flood of 1882 washed out skeletons, associated with sherds of clay pottery and iron kettles.

A section of Indian trail approximately one-half mile in length has been reported to me in the southeastern corner of the county, but not other traces of it have been located.

The remainder of the sites are simple campsites—small areas showing only slight amounts of camp debris—and are of no particular interest at this time.

We hope to be able to finish the survey this season, and although looking forward to interesting developments, it is likely that the pattern for Martin County will remain predominately at a campsite level.

The Cato Site—Pike County, Indiana

Glenn A. Black, Indiana Historical Society

In November of 1940, at the annual meeting of the Indiana Academy of Science, I read a paper entitled "Cultural Complexities of Southwestern Indiana" in which I mentioned the Cato Site. As the title of the paper implied, the problem of chronology in the pocket region of Indiana is complex and burdened by a great variety of cultural material representative of not only a long habitation period but by a variety of peoples as well. Materials are found here that are common elsewhere and fit into established patterns from which order and sequence have been established. In addition to these orderly manifestations there are others which may fit individual patterns but their associations are such as to inject a question into their relationships one with the other. In this respect the Cato Site is one of the most disquieting.

In 1940 little could be said about the site or the materials it had produced for the artifacts were in the hands of the persons who had recovered them and an opportunity for detailed study had not presented itself. Since then all, or almost all, of the objects from the site have become a part of the collections of the Indiana Historical Society.

With the artifacts came the all too meager data which had been kept by those who did the digging. The explorations were made during the winter of 1939-1940 by Revis Campbell, of Boonville, and Haskel Woolsey, of Coe, assisted by willing, perhaps too willing, visitors upon occasion.

The site is located in Section 28, Township 2 South, Range 8 West, two and one half miles west of the village of Coe on the Cato farm. It covers about an acre on the crest and north end of a ridge which projects northward into the bottoms formed by the junction of Lick Creek and the South Fork of the Patoka River. Although the site has been called a "mound" there is actually little to justify the term. At present its location is marked largely by a variation in soil color—the inhabited portion being much darker than the surrounding fields. Although materials characteristic of the Shell Mound complex are present in the collection, the site is not nearly so abundantly littered with shells as are most true shell mounds.

The collection acquired from Mr. Campbell consists of over nine hundred individual objects made up of bone, stone, shell, and clay materials. During the excavation notes were kept only in exceptional instances and they are often too limited to be of value. No photographs were taken of objects or burials *in situ* and since the site was not staked out prior to exploration there was little or no system to the digging operations.

In the paper previously referred to I stated that the Cato Site produced materials having a Hopewellian affinity. This statement was

based upon inspection of only a portion of the total accumulation of materials which had been taken from the site and which were then in custody of Mr. Campbell. After studying the entire collection I am willing to remake the same statement but will hastily add that the Hopewellian aspects of the material are dimmed and all but eliminated by a preponderance of items that are distinctly Adena in type.

When all of the collection is laid out upon tables for observation certain things stand out as indicators of more than one culture complex. These indicators are not only distinctive so far as this collection is concerned but they also constitute diagnostic traits for the individual culture complexes which might be represented at this site. It is, to say the least, somewhat disconcerting to see, reposing side by side, an antler "atlatl hook" and a limestone tubular pipe of specialized form. Or, a typical Adena gorget next to a bannerstone of the "atlatl weight" type.

Taken as a whole the collection is made up of materials usually associated with Shell Mound sites. The "atlatl hook," "atlatl weights," engraved bone pins, engraved bone beads, large projectile points made of antler, spatulate forms of bone, cylindrical pestles, beads of shell and bone, and antler shaft straighteners or wrenches.

Almost as conspicuous as the Shell Mound traits are those which serve to mark Adena. These are, first of all, a tubular pipe so perfectly Adena that it might well have been taken from any one of the type mounds of Ohio or eastern Indiana. Quatra-concave stone gorgets drilled in the usual Adena manner—from one side only. A sandstone tablet having upon each flat surface a broad shallow groove, cache discs of Harrison County flint, disc shell beads, and antler handles.

There are several items which induced me to say, in 1940, that Hopewellian was involved. These are a cut mandible, a long copper awl still inserted in its original bone handle, drilled canine teeth in large numbers, and large flint blades carefully chipped and deeply notched at the corners. In addition to these items, which are in the collection, there is an outstanding object which came from the site but which has not yet been acquired. This is a small limestone bowl, beaker shaped, having a vertical rope-like decoration carved three times upon the outer surface. Such bowls are not common in any complex but this specimen is reminiscent of Hopewellian more than any other Ohio Valley culture.

There are many objects which are always difficult to allocate specifically to any complex. Such things as bone awls, small notched points, grooved axes, scrapers, drills, antler drifts, and slate pendants might logically be a part of any one of the complexes previously named or of still a fourth—Woodlands.

To bring some order out of this chaotic situation it was necessary to group the objects according to their known association in the few instances where that was possible. Data were kept on a few of the graves encountered and the material taken from these can be properly grouped together. When this was done it became evident that many of the items which would otherwise be difficult to place in their proper category resolve themselves into well ordered patterns. It also became evident that there was a definite tendency toward grouping of items having cultural

homogeneity as would be expected. Further than this, as trait tables were prepared and handled statistically, some of the items which were considered as being representative of Hopewellian are perhaps Adena in affinity. As an example, the copper awl in the bone handle might reasonably be assumed to be Hopewellian but when it is noted that it came from the same grave which contained the sandstone tablet wiht shallow grooves then the two must belong in the same complex and in this instance that would seem to be Adena.

We might take the antler handle as another example. This type of object is found in both Shell Mound and Adena assemblages and when found alone on a site some doubt would naturally exist as to which it might be diagnostic of. But when a handle is found in the same grave with two quatra-concave gorgets, each drilled in the proper manner, then there can be little doubt but that the handle is also Adena. It would have been pleasant to be able to report that the tubular pipe, which is so typical of Adena, was found with the same burial that produced the "atlatl weight" bannerstone, or, that an engraved bone pin of Shell Mound type was found with one of the Adena gorgets, but such pleasantries are rare in archaeology and this case is no exception.

A table was prepared using only those objects as traits which were found with burials and which, therefore, could be properly associated together. Columns were set up in which each trait could be allocated for Adena, Hopewellian, Shell Mound and Lamoka Lake Site which is Ritchie's type station for the "Archaic" period in New York.

This table showed that 31 traits could be Adena, 8 traits Hopewellian, 40 traits Shell Mound, and 20 traits Lamoka. The case for a Hopewellian affinity becomes very weak when we note that there are only 8 traits which are most apt to represent that complex alone. As a matter of fact there are only two traits in the list which stand out for Hopewellian. These are the cut mandible and canine teeth drilled through from one side of the root to the nerve channel only. The limestone bowl which was referred to above was not included because it is not now a part of the collection.

There are 14 trait occurrences which might be either Adena or Shell Mound or both; 9 which might represent either Adena or Lamoka and 17 which might be either Shell Mound or Lamoka.

Not much satisfaction can be derived from a table of traits which is so inconclusive as this one. The site could hardly be representative of all three, or four, complexes. The question naturally comes up, therefore, that if this trait occurrence table is unsatisfactory and contains traits which could be representative of any or all of the possible complexss involved, what can be done about it?

There are certain items in this collection which I consider to be fundamental, or basic, and to be representative of one complex alone. As an example I would cite the tubular pipe of stone, having parallel sides, a specialized mouthpiece and bi-diameter drilling for the stem and bowl openings. This type of object is not only Adena but I believe it to be early Adena and wherever found should serve to mark that site, or burial, as Adena or at least Adena influenced. Such being so it would

seem to follow that if a burial is found, and with it a tubular pipe of this type, then that burial is Adena and those other objects which might be in association with the pipe and burial are also Adena. If such reasoning is sound, and I believe that it is, it justified the preparation of another table and grouping of those trait occurrences which can be associated without doubt. When this was done many of those traits which previously showed up as questionable markers for one or the other complex are properly and amply taken care of.

The same proceedure was applied to those traits for the Shell Mound complex. As an example, all those objects found with a burial that had with it an "atlatl weight" bannerstone were considered as forming a part of the Shell Mound assemblage.

Such a table was prepared and analyzed with interesting results. Twenty eight trait occurrences were assigned to Adena, 12 to Shell Mound and Hopewellian and Lamoka were completely elminated—each with a perfect zero.

The question of possible cultural stratigraphy within the site can be raised at this point for such a condition certainly is suggested by the figures cited above. The site may have been stratified but the methods used in the exploration were not of a nature to reveal it. The notes with the collection do not help out in this respect. It would seem, though, that stratigraphy is not the answer for there are instances in the last mentioned trait table of cross-overs of traits from one complex to the other. Examples indicate that the long antler projectile point was found in association with Adena material as well as Shell Mound material. The same is true for the cylindrical pestle and the bone spatulate tool made from the tibia of deer or elk. These items would not normally be considered as typical of Adena but when they are found with Adena material they should be so accepted.

This second table leads me to conclude that at the Cato Site we have either a late Shell Mound or early Adena occupation. That it is late Shell Mound would be suggested by the presence of small projectile points of stone and pottery. That it is early Adena is suggested to me by the presence of the tubular pipe, gorgets of stone, antler handles, and the association of these things with materials representative of the Shell Mound complex which, everywhere in the Ohio Valley underlies chronologically all other complexes. The minimum amount of shells evident at the site might reasonably indicate a drift away from a shell gathering mode of existence toward a fuller life.

Those traits which seemed too indefinite to limit them to any one complex, unless association so placed them, are probably Woodland traits and this suggestion is strengthened by a consideration of the pottery from the site, even though no sherds or bowls were reported with burials. This pottery is of two general types. The first, and oldest, is a coarse, thick, granular tempered ware having either a plain, cord marked or fabric impressed surface. Some of the sherds of this type have crushed flint as the tempering medium. The other type is also granular tempered, but is thinner walled with smaller granules mixed with the paste. It is cord marked and no fabric impressions appear on any of it. These

two pottery types are Woodlands and examples of both are produced by the oldest pottery bearing sites now known in southwestern Indiana.

Summarizing it seems to me that, in the Cato material, there is good evidence of an early Adena occupation. Evidence is suggestive of a people emerging from a Shell Mound culture into something more elaborate and based upon change in subsistence. It also seems clear that, whether the material be called late Shell Mound or early Adena matters not nearly so much as that it must be considered as representative of a transitional folk. These things, to me, seem obvious—more so than in any other site of which I am aware. It seems that both the late Shell Mound people and early Adena people were using large flint and antler points, the antler handle and even the atlatl, or spear thrower. The objection might be raised that Adena is primarily a mound building culture and that no mound was evident at Cato. This is probably true but it is equally true that Adena people need not always have built mounds. This may be one of those rare instances of a habitation site of this group—one not covered by a mound or completely eradicated by the process of mound erection as has happened so many times upon sites of this people.

Southwestern Indiana still has its "cultural complexities" not the least of which is this one. Perhaps I have worked too hard in an attempt to salvage something from this invaluable collection. If so I stand corrected, but material is of little value unless it is used and in this instance I believe the material speaks for itself.

Virginia's Indian Neighbors in 1712

J. C. Householder, Indiana Historical Society

Colonel Alexander Spotswood (1676-1740) arrived in Virginia in June of 1710, the Deputy, or Lieutenant, to George Hamilton, Earl of Orkney, the British government's official, but never resident, Governor and Commander-in-Chief of the Colony of Virginia. Spotswood (1) was very much a governor in every sense of the word, and developed into very much of an American, the type of American that broke with parent England in The Revolutionary War. After his governorship was cancelled in 1722 he spent the rest of his days in Virginia until his death in 1740; and in Virginia his children established or married into powerful families that played important roles of leadership in the late colonial and early continental periods of the State's history.

When Spotswood took over the affairs of the Colony its people were in a relatively tranquil social and political frame of mind both internally and externally, but both domestic and foreign economies were anything but prosperous. Spotswood did much to set in motion the wheels of agrarian production plus the beginnings of a manufacturing economy, at the same time regulating taxes and government supervision, to the end that for the first time in her hectic history Virginia began to build the sterling character that was developed into the flower of England's colonial possessions by the early 1770's. Also, Spotswood was a splendid military leader and a real Indian fighter; but there were few Indians to fight in Virginia.

Among the many subjects under discussion in his lengthy letter, dated from Virginia, July 26, 1712, to the Council of Trade, London, Spotswood wrote the following interesting paragraphs about the Colony's Indian neighbors:

> "Concerning the Strength of our Neighbors, I suppose to be meant of the Neighboring Indians (for there are no other foreign Nations near this Colony), in answer to which there are nine Nations of Indians Tributary to this Government, Vizt: The Pamunkys, Chickahominys, Nansemunds, Nottoways, Maherins, Sapons, Stukanocks, Occoneechees and Totteros, whose number of men, women and children do not exceed 700 in all, and of these there may be reckoned 250 fighting men. These are all in an Entire Subjection to this Government and live quietly on our Frontiers trafficking with Inhabitants their Skins and Furs for Clothing, Powder, Shot and other European manufactures. The next Nation of Indians with whom we have had frequent correspondence and who are most like to annoy us is the Tuscarurs, said to be about 2,000 fighting men. They live within the bounds of Carolina, and before the late Massacre, committed there by some of them and others, had a constant Trade with our Inhabitants for the like Commiditys as our Indians, but since that time I have prohibited all Commerce with them till they give satisfaction for the murders committed in Carolina. Besides these We have no other Nations that frequent our frontiers, and those with whom our Traders have ye Chiefest Traffique for Skins live

some 4 or 500 miles to the So. West of us and their names scarce known to any but the Traders." (2)

Spotswood's Indian problems were not, of course, either so simple or so rosy as his letter may have suggested to the Council of Trade, in London; but the fact remains that of the great Powhatan confederacy of Algonquian tribes in Virginia when the Jamestown colonists arrived, only a few poor tribal remnants remained in 1712. Of the Iroquoian Tuscarora whom his letter says "are most like to annoy us," within the year this letter was written, the Tuscarora, together with kindred Iroquoian tribes, the Meherrin and Nottoway and the Siouan Tutelo and Saponi tribes, were gathered together at Fort Christian, Virginia, and in the same year (1712) were started on their slow journey northward through the Susquehanna Valley until they finally reached the Iroquoian Five Nations tribes in New York State, by whom they were adopted. (3) This relieved the Virginians of the onerous proximity of their Carolina Indian neighbors and four of their nine immediate and tributary Virginia neighbors.

Spotswood still was faced with the task of protecting his western frontiers from the Five Nations Iroquois, particularly the Seneca, during their continual raids against the Siouan Catawba in South Carolina. He finally solved this problem by establishing compact communities of friendly Indians powerful enough to resist the Iroquois. This culminated in his treaty with the Iroquois by the terms of which they were to stay north of the Potomac river and west of the Blue Ridge Mountains. As for "ye Cattabaw and several other Southern Nations of Indians" two children from each Indian town, sons of their great men, should be delivered as hostages to Virginia, and educated at the Indians' expense at Fort Christian, Virginia. (4) During the frightful Yamasee war in 1715, in which this Muskhogean tribe lead an organized combination of most of the tribes below Charleston to the Florida border against the English, he successfully protected Virginia against the unrest this war created among the Indians closer to his frontiers.

The Governor foresaw serious difficulties with the Spaniards in Florida, and to settle them with vigor and dispatch advocated to the British government the seizure of Florida. Likewise he raised a powerful voice on behalf of English interest west of the Alleghanies, and to this end suggested to London the establishment of a chain of forts from the eastern Great Lakes to the Mississippi river as a bulwark against the French. Spotswood splendidly typified the spirit of the English colonists. They were empire builders. The Indians had little chance against them. At the first opportunity the Red Men were disposed of. True, William Penn did his part in a rather polite manner, but the English from Maine to Georgia came to build an English civilization, and the Indians were to have no part in it. The same thing happened when the post Revolutionary Americans crossed the mountains into the Ohio and Mississippi valleys. The French, on the other hand, were willing to temporize and compromise with the Indians. They were ready and willing to live with them, and to share the Indian formula of culture so long as the fur trade and its enormous profits lasted. The Spaniards were

nothing more nor less than plunderers and murders. The English were empire builders, the French adventurers, the Spanish destroyers. The fate of the American Indian was a hard fate.

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3. Weer, Paul, 1937. Preliminary notes on the Iroquoian family, Indiana Historical Society, Prehistory Research Series, Vol. 1, No. 1 (Indianapolis) pp. 8-9.

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On the Physical Types of the Shoshonean-Speaking Tribes

GEORG NEUMANN, Indiana University

The racial history of the Indian tribes of the so-called Shoshonean linguistic area is one of the least known of the continent. This is reflected by the paucity of published data from this vast area, which extends from the northern part of the Great Basin to the coast of southern California. Like most other areas this one has had a complex history despite the fact that the cultures found in it are as a whole relatively simple. This has not been brought out in connection with the published data on skeletal material from this area, and for this reason needs clarification.

When Hrdlicka published the second section of his *Catalogue of Human Crania*,[1] he included a section dealing with the skulls of Shoshonean tribes, and on the basis of a series of twenty-six male and fourteen female skulls from this area postulated a Shoshonean type. Having excluded the crania of individuals of Shoshonean-speaking tribes of southern California and Hopi crania, he then describes this type (p. 101) as follows:

1. The tribes of this group, as far as represented, show a fairly uniform type.
2. This type is characterized by—
   Mesocephaly;
   Low to medium height of the vault;
   Medium face, orbits, and nose.
3. The type is not far from the Algonkin, but differs from this by a perceptibly lower vault.

Further on, after describing the crania of California tribes (p. 127), we find the statement that this type appears to be practically identical with that of the Shoshoneans. A Shoshonean-Californian type is thereby established, which, however, still excludes the Hopi, who are considered with Pueblo groups of the Southwest.

Next we may consider the linguistic basis for such a grouping, and whether it is affected by the extension of the stock. Since the establishment of the physical type, the evidence of comparative linguistics has shown that the Shoshonean grouping on the order of a stock must be abandoned. A more inclusive category, Uto-Aztecan has taken its place, including such languages as Luiseño, Cahuilla, Serrano, Tübatulabal, Pima-Papago, Hopi, Ute-Southern Paiute-Chemehuevi-Kawaiisu, Shoshoni-Comanche-Gosiute-Wind River-Panamint, Mono-Bannock-Snake-Northern Paiute, and Nahuatl. Hyphenated names indicate a single

[1] Hrdlicka, Ales. Catalogue of Human Crania in the United States National Museum Collections. The Algonkin and Related Iroquois; Siouan, Caddoan, Salish and Sahaptin, Shoshonean and Californian Indians. Proceedings of the United States National Museum, **69**, 92-101, Washington, D.C , 1927.

language; intermediate groupings, that is, the grouping together of a number of these languages within the stock, have not been made as yet. In other words, Luiseño and Tübatulabal of southern California may be less closely related to each other than Tübatulabal to Nahuatl. Formerly Luiseño and Tübatulabal were grouped together as Shoshonean, while Nahuatl was considered a language of a separate linguistic stock—Nahuatlan.[2]

At first glance it would appear that there should not be any fundamental objections from the physical side to this extension, thus making a linguistic stock and physical variety almost coterminous, especially since races of an older dolichocranial stratum are to be found along the western side of the continent from British Columbia to Central America. In fact, von Eickstedt[3] suggests such a grouping under the name Margid race. One would soon find, however, that such wide pooling of material would be of little use in detailed historical reconstruction of the relationships and movements of prehistoric groups of this region. Practically all differences would disappear in non-existent averages which would be meaningless in wider comparisons with the Fuegid and Lagid varieties of South America. To the north within the Shoshonean area, Sylvid admixture is found extending to the Pacific coast. This is swamped by a later overwash of the southward expanding Pacifids,[4] giving rise to the Prairids to the east, and sending offshoots such as the Apache and Navaho far to the south. This Pacifid expansion also makes itself felt in northern California—a fact that is ignored by Hrdlicka in classifying all California crania into a single type—and appears as a hybrid type among northern Shoshoneans. Older Centralid elements were evidently swept along by the Pacifids, later to become settled in central California, and as Hopis in Arizona. The oldest element, represented by the California Mission Indians, differs widely from the Centralids and Pacifids and may not be too closely related to the Pima, Papago, and extinct tribes of Lower California. In Mexico the originally Margid Aztecs, whose closest relatives may have been the Tarascans from a racial point of view, became extensively mixed with Centralid Toltecs. Thus through various contacts with surviving older groups or expanding later ones, each tribe has a little different racial history which has to be examined individually in the light of archaeological data. It follows from this that the application of a linguistic name—Shoshonean—to a variety of Man would be misleading, and Hrdlicka's median values for nearly all averages suggest a too inclusive nature of his grouping. Until more is known of the composition and relationships of this larger group, I would retain for it the term Margid variety, an appelation that has no linguistic or cultural connotations.

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[2] Thomas, Cyrus and John R. Swanton. Indian Languages of Mexico and Central America and Their Geographical Distribution. Bureau of American Ethnology, Bulletin 44, Washington, D.C., 1911.

[3] Von Eickstedt, Egon. *Rassenkunde und Rassengeschichte der Menschheit*, Stuttgart: F. Enke Verlag, 1934, p. 709.

[4] *Ibid.*

Lastly I would like to indicate in a few words how the prehistoric skeletal material from Catlow Cave No. 1 fits into the above sequence of types. This cave in which Cressman[5] discovered a skull which promises to be of some antiquity is located in Harney County, Oregon, and hence in the northernmost part of the Shoshonean area. For this reason Cressman as well as Hrdlicka, to whom the skull was submitted for description, compared the specimen with known Shoshonean ones.

In this report Hrdlicka did not use the term Shoshonean type but substituted "oblong-headed West Coast strain." Hooton, to whom the skull was submitted for study later, in general concurs in that he identifies it as being of the Basket-Maker type of the Southwest. At the end of the report Cressman gives a table of measurements of adult male "Shoshonean" crania from the U. S. National Museum collections. These already represent a number of varieties: Piegan and Blackfeet which probably are predominantly Sylvid; Steins Mountain, which may be Pacifid, Centralid, or Prairid; and the rest probably predominantly Margid. The exact identification as to variety of the Steins Mountain skull and a series from Blitzen valley, Oregon, which is also appended to the report, is not possible as neither height measurements[6] nor morphological attributes are listed. Nevertheless, despite of the heterogeneous nature of the U. S. National Museum series there are enough Margid skulls among them to indicate the difference between Margids and such a series as that from Blitzen Valley. This difference is of about the same order as that between the skull from Catlow Cave No. 1 and the Blitzen Valley series—a divergence which Cressman notes in his comments.

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[5] Cressman, L. S. Archaeological Researches in the Northern Great Basin. Carnegie Institution of Washington, Publication 538, Washington, D.C., 1942, 141-143.

[6] Neumann, Georg. American Indian Crania with Low Vaults. Human Biology, 14, 178-191 (1942).

Passamaquoddy and Quapaw Mnemonic Records

Paul Weer, Indiana Historical Society

The records of the preliterate American Indians were transmitted from generation to generation by word of mouth by a group of elder record keepers who, at the same time, instructed certain qualified young men of the new generation to carry on after them. This was accomplished by committing to memory the national or tribal chronicles: history, legend, and folklore; but, to assist the memory, systems of mnemonic devices were often invented. The Walam Olum of the Lenape represents this practice carried to the highest point of accomplishment. The two cognate examples cited here do not have the historical depth nor the breath-taking sweep of historical continuity found in the Walam Olum. Nevertheless they do add to our present accumulation of knowledge some additional information concerning this Indian method of continuing through the present and into the future the history of the past.

The Walam Olum, or Painted Record, of the Lenape is the most outstanding attempt of preliterate Indian tribes of the United States to document their past, so far known to have been preserved. In addition, the record has a most interesting history, since its discovery. The mnemonic sticks are reported to have been found among the Lenape (Delaware) Indians living along White river, in Indiana, in the year 1820. The words relating to them, written in mixed modern and ancient Lenape probably by an (European) educated Lenape chief or a keeper of the records, were obtained in Kentucky in 1822. Both sets of material were acquired by Constantine Samuel Rafinesque during his Kentucky residence (1819-1826); and, fortunately, were included in the small portion of his collections he was able to take with him when he left Kentucky in the latter year and returned to Philadelphia to spend the rest of his days. With the aid of dictionaries prepared by David Zeisberger and John Heckewelder, famous Moravian missionaries to the Lenape, Rafinesque finished his translations in the year 1833, and published his texts in 1836, "*American Nations*" (Philadelphia).

Fifty years later, Daniel G. Brinton, in his "*Lenape and Their Legends*" (Philadelphia, 1885), brought to light the Rafinesque treatise, and after a long thorough reexamination, under the advantages of his own scholarly qualifications for such a task, confirmed the elder scholar's conclusion that the Walam Olum was a genuine Indian creation of great value.

Brinton deposited the original Rafinesque manuscript, carrying drawings of the pictographs and the written words, in the University Museum, at Philadelphia; and left to future generations this suggestion: The Walam Olum "will repay more study in the future." Now, sixty years after Brinton, this obligation is being undertaken by the Indiana Historical Society, because, first, the Lenape "Painted Record" is part of

Indiana's heritage from her native inhabitants of the long ago; and, second, the establishment of the authenticity of the record and its detailed collation with present known data will throw a flood of new light upon the prehistory of America. The Walam Olum is in fact a great chronicle of the Lenape nation from its earliest ancestral Algonquian days. Beginning before the Lenape themselves had become differentiated from the parent body, the five songs recite the story of creation, give the flood legend, report the crossing of Bering Strait from Asia to America, and continue through two lengthy songs to recite the story of their conquests and cultural growth as they travel, for generation after generation, across the American continent until the Lenape proper establish themselves in "Sassafras Land" on the banks of the river Delaware where they were found by William Penn in 1682, and by the Swedes and the Dutch and the Virginian John Smith earlier in the same century, and probably by Verrazano in 1524.

The Passamaquoddy mnemonic records (1) were created by the combinations of various colored wampum beads arranged in long strings thereof. These strings were obtained by Dr. J. Dyneley Prince, at Bar Harbor, Maine, in the year 1887, from a Passamaquoddy Indian, Louis Mitchell, who was at that time an Indian member of the Maine legislature.* With the strings Mitchell gave Prince the Passamaquoddy text written syllabically without arranged divisions into words, sentences or paragraphs, and a translation of the text into English. The records deal first with the formation of a league of peace; and then continue not as history, but as the prescribed ceremonials to be instituted at the death of a chief; the ceremonies of electing and installing a new chief; the ancient rites of the marriage ceremony; and, lastly, the marriage ceremony in later days. There is apparent continuity in the records, for they begin with the peace treaty and continue thereafter with the "Wampum Laws" which, at least theoretically, were written as part of the treaty. Without doubt there were many more Passamaquoddy "Wampum Laws" than the few obtained by Prince in 1887. The story of the peace treaty is divided into two "Wigwams." When the delegations are finally assembled, for the first seven days a great silence is observed by all the participants, that they may meditate on their speeches. This is called the "Wigwam of Silence." The period of speech making is the "Wigwam of Oratory."

The Passamaquoddy belonged to the northeastern group of Algonquian tribes known collectively as the Wabanaki. When first found by the whites the Passamaquoddy lived on Passamaquoddy bay and along the St. Croix river on the boundary between Maine and New Brunswick. The Wabanaki included, to the west of the Passamaquoddy in order, the Malecite, the Penobscot, the Wawenock, and the St. Francis Abenaki (formerly the Norridgewock, Aroosaguntacook, Sokiki, and other remnants). To the east of them, marginal but still belonging to the Waba-

* The Passamaquoddy and Penobscot tribes were permitted to send a representative to the Maine legislature to speak only on affairs connected with the Indian reservations in that State.

naki group, were the Micmacs (2). All of these tribes possessed a similar simple hunter-fisher Northern Algonquian culture, diminishing in complexity from west to east (3). The Wabanaki lived, literally speaking, in perpetual war with the Iroquois to their west. The Wabanaki were more than the fighting equals of their enemies, and were more annoyed than frightened by them. Consequently, after generations of indicisive wars with the Wabanaki, the Iroquois tried to bring them into their league. The Wabanaki had a loose federation among themselves, and therefore were not altogether unprepared to consider a proposition of larger scope. Finally, about 1700, the Wabanaki tribes, more through good judgment than fear of their enemies, ceased hostilities; and the Passamaquoddy, Penobscot, Malecite, and Micmac sent delegations to the Iroquois and entered into a more or less permanent league relationship with them (4). This was consummated at the great peace treaty at Caughnawaga. As the translated wampum text reads: "The father ruling the wigwam was the Great Chief who lived at Caughnawaga." (5) Therefore, the wampum mnemonic records reciting the preliminary steps of calling the delegates, their assembly, and on through the "Wigwam of Oratory" with which the league covenant is concluded, can be dated about 1700. Moorehead found wampum in Indian graves in Maine. Dating the other "strings" which relate to ceremonial practices would, conceivably, suggest a linguistic problem. The "string" describing "The marriage in later days" obviously is of late historic origin.

The Quapaw record is less authentic, one may well say apocryphal. On the authority of a Dr. J. L. LaRue (6), Belva, Arkansas, Mr. Higgins, an English mining engineer, "found secreted in a cleft of the rocks on the northwest angle of the Pilot Mountain, located in Scott County, Arkansas, 212 slate tablets, with three pictures on each side. There were 1,272 pictures in all. . . . The pictures portray a history of the Quapaw Indians during the reign of Queen Singing Bird the First, or the good queen, as she was called by the Indians." (7) Concerning the slate pieces it seems that Mr. Higgins shipped them to England and received in return for them the sum of two thousand dollars. Shortly thereafter Higgins was found dead, and was buried near Sugar Grove, Logan County, Arkansas. But before this tragic exit Dr. LaRue was permitted to copy the pictures.

We will now quote the good doctor, for no one else could possibly give the subject equal glamor: (8)

> "I cannot give you the dates; but it was before the introduction of fire arms. It tells of the massacre of the Spanish miners, and gives a graphic account of the bloody battle fought between the Quapaws and Chickasaws, near where the city of Little Rock now stands. The Chickasaws were defeated and driven back east of the Father of Waters. Also the appointment of the gifted young chieftain, Silent Tongue, to the office of ambassador to frame a treaty of peace with the Chickasaws. Gives an account of his journey, his friendly reception, the ceremony of burying the tomahawks, and the speeches made on the occasion. It gives the manners and customs of the Quapaws, their religion, and form of marriage. There were two tribes of Indians incorporated in one nation, and ruled over by the Sun Chiefs. Their government was constitutional monarchy. The legislative body was composed of a house of warriors,

and a house of chiefs. . . . There is history, religion, romance, manners, customs, ceremonies, speeches, and an account of a trial before the queen."

The Quapaw were a tribe of the Siouan language family, and according to their own traditions once lived in southwestern Indiana along the Ohio river near the mouth of the Wabash. There is no reason to believe that they could not have developed a mnemonic system for the keeping of records. So far as the fanciful tale reported here is concerned, the writer of this paper wrote to the Society in whose early volume it was published with other Indian items under the title "Aboriginal and Indian Remains." The present officers of the Society know nothing about the facts published in the aricle on the subject of the Quapaw record. If the record was genuine in any respect whatsoever, it was, of course, of modern origin as the subject matter clearly indicates. It might be the modern survival of an ancient Quapaw mnemonic system now long since lost and forgotten.

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BACTERIOLOGY

Chairman: C. M. PALMER, Butler University

The BACTERIOLOGY SECTION met with the Indiana Branch, SOCIETY OF AMERICAN BACTERIOLOGISTS.

Mr. F. A. Miller, Eli Lilly and Co., was elected chairman of the section for 1946.

Some of the factors influencing death from gas gangrene. VERSA V. COLE, H. R. HULPIEU, and L. A. WEED, Indiana University.—The factors in death from gas gangrene which have been recently investigated are: total carbon dioxide content of blood, blood sugar, temperature of the infected region, and narcosis of the animal. None of these have shown an effect on death rate. All except the blood sugar seemed to exert some effect on survival time. Infection with Clostridium welchii lowered the carbon dioxide content of the blood up to death. However, those dogs which had a high normal carbon dioxide content had a shorter survival than those which had a low normal carbon dioxide content. Blood sugars at death were usually low. The survival time was increased by narcosis and was further increased by cooling the infected region.

A dichotomous key to the species of the genus bacillus. C. M. PALMER, Butler University.—A key to the species of the genus Bacillus has been formulated which is dichotomous and more complete than the types such as are presented in Bergey's Manual of Determinative Bacteriology. Nine groups of species are first distinguished and keys to the species in each group (excepting the thermophilic) have been constructed. Care has been taken to use clearly recognizable distinctions throughout the key.

Influenza virus vaccine for general use. H. M. POWELL, Lilly Research Laboratories, Indianapolis, Indiana.—Experimental evidence is presented that influenza virus vaccine, types A and B, can be prepared on a large scale with much greater yield than similar vaccine for military use has shown heretofore. This may make this vaccine practicable for general use, provided the actual results in prevention of influenza are finally satisfactory.

Greater yield is obtained by using more than the customary one-tenth volume of saline in eluting the virus following its adsorption on red blood cells during the process of purification of the raw virus-containing periembryonic chick embryo fluids. Resultant vaccine when given in two weekly doses of 0.1 cc each to Swiss mice immunizes against 10,000 LD 50 of active type A mouse lung viruses, and when given in two weekly doses of 0.001 cc each to Swiss mice immunizes against 1,000 LD 50 of active type B mouse lung virus.

An Agar Decomposing Organism Isolated from Soil

F. Joseph Murray, Purdue University

A complex carbohydrate, agar is attacked by very few organisms and in text books published as recently as 1900 we find the statement that agar is not liquefied by any organism. Since that time a few agar decomposing organisms have been reported in the literature, the first being a species isolated from sea water and described by Gran in 1902. This organism, which has been named *Bacillus gelaticus*, (1) occurs in three varieties distinguished by chromogenesis and requires a high salt concentration when grown on artificial media. In 1905 Panek reported an acid producing rod which had the ability to liquefy agar and this is now known as *Bacterium betae viscosum.* Biernacki in 1911 isolated an agar decomposer from raisins and this organism, also an acid producing rod, was named *Bacterium nenckii.* (2) Perhaps the best known of the agar decomposers on record is that reported by Gray and Chalmers in 1924, a cellulose decomposer, this organism is known as *Microspira agar-liquefaciens* (3). The most recent report of such an organism is that of Stanier, (5) his description of *Actinomyces coelicolor* having appeared in 1942.

Attention was drawn to the organism here reported during experiments on cellulose digestion by soil organisms from the grounds at Purdue University. Active digestion of cellulose was observed in an aerated flask and plates were made in an attempt to isolate the cellulose-attacking organisms. The medium used was one reported by Dubos (4) as favorable for the growth of cellulose digesters and consisted of the following:

$Na\ NO_3$	0.50 gms.
$Ka\ HPO_4$	1.00 gms.
$Mg\ SO_4.\ 7H_2O$	0.50 gms.
K Cl	0.50 gms.
$Fe\ SO_4.\ 7H_2O$	0.01 gms.
Distilled water to 1000 ml.	

To the basal medium, agar was added to give a concentration of 1.5 per cent and filter-sterilized glucose was added directly to the plates in a concentration of 0.1 per cent. These plates were observed to contain many definite depressions with small yellowish deep colonies occupying the center of each and every depression. Since it was a mixed culture, there were many other organisms growing on the surface and isolation presented a problem. Various media were tried and while growth of the organism took place on many of these, the phenomenon of agar digestion was most satisfactorily observed on the original Dubos medium plus a 1.5 per cent concentration of agar. However a pure culture was obtained from surface colonies appearing on a medium en-

riched with a nutrient substantially the same as corn steep liquor, streaks from these colonies giving rise to the depressions on Dubos medium.

Platings of the organism give rise to yellow and white colonies with the white predominating. These colonies in turn are capable of giving rise to more yellow and white colonies both types resulting from either a yellow or white colony. Microscopically, stains of organisms from both colonies present a similar picture in that both are gram negative, non spore forming rods measuring 0.5 μ by 2.0 μ and possessing true motility. Stains from the yellow colonies, however, reveal some spindle-shape cells and it is thought possible that the difference in color is related to an age factor.

The organism fails to ferment carbohydrates with the production of acid and gas, nor does it attack cellulose. Mesophilic with an optimum temperature of 30°C, the organism is aerobic to microaerophilic and grows readily on potato with a characteristic yellow pigment. Litmus milk is reduced after two days, while indole, Voges-Proskauer, and methyl red tests are all negative and there is no reduction of nitrates.

There were no evidences of liquefaction around the depressions and a test devised by Gran making use of an iodine-potassium iodide solution failed to demonstrate liquefaction.

Varying the concentration of glucose disclosed that higher levels such as 2 per cent resulted in increasing amounts of growth, but the degree of decomposition is far less at this concentration than at the 0.1 per cent level.

It was found that growth of the organism depends upon the method of sterilizing the glucose, normal growth taking place when the glucose is filter sterilized and growth being inhibited to a very great degree with autoclaved glucose. Stanier has reported similar results with organisms of the cytophoga group and he explains it as a toxic effect of caramelization products even though the glucose is separately autoclaved in pure distilled water. This explanation seems the most satisfactory at this time.

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BOTANY

Chairman: R. E. GIRTON, Purdue University

Professor J. E. Potzger, Butler University, was elected chairman of the section for 1946.

The growth of Oenothera plants from embryos cultured in vitro. RALPH E. CLELAND and MARGARET NEWCOMB, Indiana University.—Notable progress has been made in recent years in the cytogenetic analysis of Oenothera and in the application of cytogenetic methods in the study of phylogenetic relationships. This work has been largely confined, however, to the subgenus *Onagra (Euoenothera)*. It is highly desirable to analyze other subgenera and to bring them into the same system with *Onagra*, thus gaining an understanding of the larger relationships existent in the genus.

This has hitherto proved impossible, however, because of the extreme difficulty encountered in hybridizing races from different subgenera or from different species of the same subgenus. There is evidence that this difficulty is the result, in some cases at least, of arrested development of the hybrid embryos. We have attempted to overcome this difficulty by excising hybrid embryos before they have become arrested and growing them in vitro. While the work is still in its infancy, some success has been obtained in that a number of interspecific hybrids otherwise unobtainable have been brought through to advanced stages of development. In one case, a hybrid has been brought through to flowering and its chromosome configuration has been obtained.

A brief description of the methods of excision and culture was given.

Planting forest trees in Indiana. DANIEL DENUYL, Purdue University.—There have been used for reforestation in Indiana 46 different species of trees; 23 hardwoods and 23 conifers, including cypress and larch. The most important factor that has influenced reforestation is the selection of species to be planted. The results of studies to determine what species of trees are best suited for reforstation show that for open field planting red pine, white pine, jack pine, virginia pine, shortleaf pine and black locust are most desirable.

Red pine *(Pinus resinosa)*. This species is adapted to a wide range of planting sites and can be planted on nearly any site except badly eroded areas, extremely dry sites and poorly drained areas. It appears to be the best tree to use if a good stand of pine is desired.

White pine *(Pinus strobus)*. It will grow on most sites except those that are poorly drained, extremely dry or badly gullied. It grows best in moist, protected locations.

Jack pine *(Pinus banksiana)*. It will grow on nearly every site. It grows rapidly and provides a quick effective tree cover.

Virginia pine *(Pinus Virginiana)*, short leaf pine *(Pinus echinata)*. Both species are adapted for planting on worn-out, eroded lands of Southern Indiana, where they provide very quickly a dense cover for protecting the soil.

Black locust *(Robinia pseudoacacia)*. It attains its best development on well drained sites and is not adapted for planting on all eroded and depleted soils.

The planting of conifers on non-agricultural soil in Indiana appears to be the best and quickest way to eventually secure through natural succession a stand of native hardwood trees.

Plants of Cabin Creek bog, Randolph county, Indiana. RAY C. FRIESNER and JOHN E. POTZGER, Butler University.—This bog, located at the junction of Cabin Creek and state road 1, about one mile south of Farmland, is outstanding in that it is of the "raised" type. The highest elevation of the deposit, near the center of the bog, is ten feet above the margins. The elevation is associated with numerous artesian wells which flow off in three continuously flowing streams. The deepest peat and marl deposit is 33 feet. The bog is also significant from the standpoint of its vegetation, having a large number of species with disjunct distribution. Among these are: *Chara brittoni*, known elsewhere only in La Porte county Indiana and from the type locality in New Jersey; *Melica nitens, Panicum implicatum, P. albemarlense, Hierochloe odorata, Muhlenbergia setosa, Triglochin palustris, Rhyncospora capillacea, Eleocharis rostellatus, Salix lucida, Tofieldia glutinosa, Melanthium virginicum, Gerardia paupercula, Chelone glabra* var. *linifolia* forma *velutina, Lobelia kalmii*, and *Solidago ohioensis. Viburnum dentatum* var. *deamii* reaches its northernmost limits here.

Some trace element deficiencies in rice. NOE HIGINBOTHAM, University of Notre Dame.—Nutrient solution experiments with rice indicate that it may be added to the growing list of plants requiring boron, manganese, and copper. Boron deficiency symptoms are distinctive but resemble calcium deficiency in the appearance of chlorotic spotting of the leaves as they emerge at the tip. Manganese deficiency first appears as a chlorosis of the midvein leaf areas thus resulting in a striping of the young leaves. The minus copper plants showed no characteristic symptoms but they showed a lower dry weight than control plants. Additional experiments with boron indicate that it is essential for normal grain production and that its utilization in the plant is related to calcium supply.

The use of embryological formulas in plant taxonomy. THEODOR JUST, University of Notre Dame.—Significant stages and types of gametophyte development and embryology in flowering plants can be indicated by various symbols which in turn are grouped together as "embryological formulas." These express the available embryological data concerning any group as effectively as floral formulas convey the structure of flowers. Both types of formulas are valuable aids in the study of plant relationships.

Ecological study of the Kleine Woods, Jennings County, Indiana (Illinoian till plain). CARL O. KELLERT, Indianapolis Lutheran Schools.—The Kleine Woods is an area comprising 120 acres, located in the north central part of Jennings County. It is a remnant of the forest primeval which once covered the southeastern section of the state. Its composition is similar to that of other Illinoian till plain areas which have been studied, being a type of the mesophytic climax forest of Indiana.

In this survey, 30 different woody species were found. Of these, 14 are tall trees, 6 small trees, 3 shrubs, and 7 lianas. The dominant tall tree species in decreasing order of importance, as shown by basal area, are: *Quercus palustris*, 27.05 per cent; *Quercus alba*, 21.69 per cent; *Fagus grandifolia*, 21.61 per cent; *Liquidambar styraciflua*, 9.5 per cent; *Nyssa sylvatica*, 6.58 per cent; and *Acer rubrum*, 6.24 per cent.

Sassafras variifolium is the most important species among the small trees, and *Lindera benzoin* leads in the shrub layer.

This study is based on 50 100-square-meter quadrats. Ecological factors considered are frequency, abundance, and basal area.

A revision of the "punch-card" method for the identification of gilled mushrooms. C. L. PORTER, Purdue University.—The punch card method of mushroom identification was reported previously to the Academy. The punch cards and the arrangement of characters were demonstrated at the earlier meeting. Since that time, use of the card has suggested improvements in the method. The improvements include a change in the nature of the card; a rearrangement of characters; the elimination of some characters and the addition of others. The changes and the reasons for them are explained in this revision.

A primitive characteristic in corn from Peru. PAUL WEATHERWAX, Indiana University.—Three varieties of corn grown on the Peruvian plateau show peculiar orientations of the grains, due to the full development of the normally aborted lower flower of the spikelet.

These are described, and their theoretical significance is discussed.

Some agricultural problems of the high Andes. PAUL WEATHERWAX, Indiana University.—Many of the modern economic staples of the Andes were grown there by the Indians in pre-columbian times, and practices as to their cultivation and use have changed very little.

A brief account will be given of recent studies there with a statement as to the present status of the question of the origin of the Indian corn plant.

Some Concepts of the Respiration of Seed Plants

RAYMOND E. GIRTON,* Purdue University

In elementary botany and biology courses one occasionally hears the questions asked: "Do plants breathe?" "Is respiration the same as breathing?" "Are stomata breathing pores?" These and similar questions reveal widespread ignorance about the import and true nature of plant respiration.

Meaning of Respiration.

If we look into the meaning of the term "respiration" we find that it has its origin in the Latin prefix "re-" meaning back and the Latin verb "spiro" meaning to breathe. To respire, therefore, in the original meaning, is to breathe back, or to breathe in and out—that is, to inhale and exhale. In other words, respiration, in this usage, is synonomous with breathing.

Plants, however, do not breathe in the true sense of the term. It is conceivable that the nearest approach to actual breathing in seed plants is the result of wind which produces a swaying and bending of the stems and of the leaves also. This compression and expansion of stem and leaf tissues may produce a slight bellows action and cause a forceful exhalation and inhalation through lenticels and stomata, similar to the forced breathing in man when artificial respiration, or resuscitation, is used. Aside from this instance, the exchange of gases in plants is a diffusive process and cannot be catalogued as "breathing."

What, then is the modern usage of the term "respiration" as applied to plants? Meyer and Anderson (1939) in their text *Plant Physiology* have a clear answer to this question. They state that "plant physiologists use the term respiration primarily to refer to the oxidation of foods in living cells resulting in the release of energy." Other authors of current textbooks (Miller, 1938) and of monographs upon plant respiration are essentially in agreement with this interpretation as applied to plants. We have, therefore, emphasis placed upon a metabolic process, largely chemical in nature, whereby energy is released through the oxidation of foods within living cells. Such a definition is broad enough to include both aerobic (or oxygen) and anerobic forms of respiration.

Certain Factors and the Respiratory Gas Exchange.

Much of the early study of plant respiration was concerned with the influence of certain factors, chiefly external, upon plant respiration or upon related processes dependent on respiration. Since the exchange of gases is the outward sign of inward respiratory activity, the first step

* The writer wishes to thank the following individuals for reading the manuscript: Professors A. T. Guard, H. B. Knoll, C. L. Porter, and P. A. Tetrault

in building up a knowledge of plant respiration involved the discovery and demonstration of such an exchange. This discovery, in turn, waited upon the identification of the gases concerned in respiration. Therefore, although the Italian physician and plant anatomist Malpighi as far back as 1679 pointed out that seeds require air for their germination, progress in the subject was obliged to wait for the discovery of oxygen by Joseph Priestly in 1774. Three years later, the Swedish chemist and co-discoverer of oxygen, Scheele, was able to show that germinating seeds absorb and utilize oxygen and, at the same time, produce carbon dioxide. In 1779 the Dutch physician and plant experimenter, Ingenhousz, demonstrated that all living plants evolve carbon dioxide in darkness and that non-green plants also evolve carbon dioxide in the light as well.

A marked step in advance came with the introduction of quantitative methods of study by the Swiss plant physiologist and chemist, De Saussure, as illustrated by work published between 1797 and 1822. De Saussure measured the gas exchanges in germinating seeds and in darkened leaves, and compared the rates of oxygen consumption with those of carbon dioxide production. He found that frequently, but not always, these gases were exchanged in equal quantities. De Saussure also studied the production of water and of heat in plant respiration. Both of these he correlated with the measurable gas exchange.

Respiration is one of several physiological processes which are markedly influenced by temperature. Bonnier and Mangin in 1884 found that plant respiration, as measured by carbon-dioxide production, increases regularly with increased temperature until it finally reaches a maximum value where it remains at the same level until the death of the plant takes place at about 50°C. It was thus shown that plant respiration has no true optimum temperature.

Internal as well as external factors have also received study. Palladin, at the turn of the century, published a report of the relation of carbohydrate supply to respiratory activity. He found that when starved, etiolated leaves were floated on sugar solutions their original low rate of respiration increased many fold. Sugar supply thus may limit respiration. The work of Spoehr and McGee (1923) concerned another and perhaps unexpected internal factor which may markedly influence respiration. These writers found that in leaf tissues wherein carbohydrate supply was adequate, increased respiration rates could be obtained by adding simple amino acids.

The contributions of the foregoing men, and of many others not mentioned, illustrate the slow gathering of knowledge concerning the general nature of the respiratory gas exchange and also the influence of various factors upon this process. As a result of these findings, speculation regarding the meaning of the observed phenomena began to develop. Some of the ideas put forward have been abandoned in the light of wider knowledge. Other concepts have been modified and retained as the result of further studies and still others are now in the process of formulation, testing, and modification.

Respiratory Concepts.

One concept which seems to have been widely held over a period of forty years is that of "double respiration." Following, and in spite of, the careful work and reasoning of De Saussure, the idea became widespread that plants carry on two distinct forms of respiration which alternate during the twenty-four hour day. Thus it was thought a "diurnal" respiration took place during the daylight hours and a "nocturnal" respiration took place during the hours of darkness. The diurnal respiration was characterized by the absorption of carbon dioxide and the evolution of oxygen. The nocturnal respiration, on the other hand, resulted in the reverse gas exchange—that is, the absorption of oxygen and the evolution of carbon dioxide. This misconception can be attributed to the use of the term "respiration" for both gas exchanges. Thus, as we now know, the actual daylight respiratory gas exchange was overlooked because it was masked by the greater magnitude of the reverse gas exchange of photosynthesis.

It remained for the German plant physiologist Sachs to sound the death knell for this double-respiration concept. Sachs in 1865 emphasized what had been shown previously by others—that two separate processes contribute to the carbon-dioxide-oxygen gas exchange, namely, photosynthesis and respiration. To quote Stiles and Leach (1936) in their monograph *Respiration in Plants*, "Sachs pointed out what he later called 'the scarcely conceivable thoughlessness and obtuseness' in speaking of a double respiration of plants—of a so-called nocturnal respiration, by which was understood the evolution of carbon dioxide which occurs in true respiration."

Another nineteenth-century concept advanced in 1878 by the German botanist Pfeffer, and later abandoned by him, was the belief of a direct connection between fermentation and aerobic, or oxygen, respiration. This concept has been called the "Theory of Connection." It was borrowed from the animal physiologist Pflüger, and applied to plants by Pfeffer. Pfeffer's idea was that normal plant respiration consisted of two steps. The first step could take place under anaerobic conditions and yielded both alcohol and carbon dioxide. It was therefore considered to be identical with yeast fermentation. The second step was aerobic in character and oxidized the alcohol produced in step one completely to carbon dioxide and water. The fermentation process, therefore, was looked upon as the natural first step in the normal oxygen respiration of seed plants. (Fig. 1.)

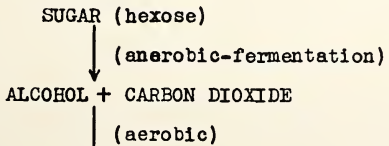

Fig. 1 Pfeffer's Schema

In line with this concept, it was supposed that one-third of the carbon contained in the original sugar appeared as carbon dioxide in the fermentation step. This would represent the maximum yield of carbon dioxide under anaerobic conditions, as in an atmosphere of pure hydrogen, for example. The second step, which was dependent upon the presence of free oxygen, converted the carbon of the alcohol product to carbon dioxide so that all of the carbon of the original sugar would appear as carbon dioxide. Therefore, the ratio of carbon dioxide respired by plants in hydrogen to that produced in air should be one to three. This ratio could not be verified experimentally, perhaps, because of the toxic effects of the anaerobically accumulated alcohol. Also, it was shown that alcohol is less easily oxidized by plants than sugar. For these and other reasons Pfeffer virtually abandoned the view that alcoholic fermentation constitutes a part of normal seed-plant respiration. He said in 1897 as quoted in Kostyschev's (1927) *Plant Respiration*: "These primary causes, which in normal respiration bring about the oxidizing action of oxygen, in the absence of free oxygen . . . effect reactions which *did not take place* wholly or in part, reactions out of which arise carbonic acid as well as other products of intramolecular respiration."

In spite of the fact that Pfeffer himself gave up the theory of connection, the fundamental idea back of it was not dead. In 1910 and the following years, the Russian physiologist Kostyschev advocated a modification of Pfeffer's concept. (Fig. 2.) Sugar (hexose) is again

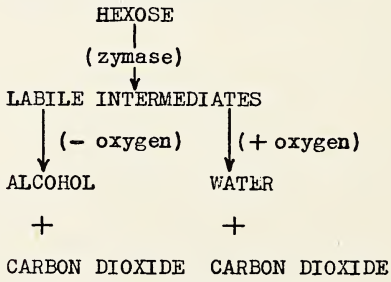

Fig. 2 Kostyschev's Schema

the starting point of his theory and under the action of zymase, demonstrable in plant tissues, produces certain labile compounds intermediate in the process of fermentation. Such compounds as acetaldehyde and pyruvic acid have been suggested as probable intermediates.

Following this first step, which is anaerobic in nature, the intermediate compounds in the presence of oxygen become oxidized to carbon dioxide and water. In the absence of free oxygen, however, some of these intermediates undergo oxidation and some undergo reduction yielding the typical fermentation products of carbon dioxide and ethyl alcohol.

Kostyschev's modification overcame at least some of the objections to the original concept. For example, the difficulty of securing a rapid oxidation of alcohol by seed plants is obviated by assigning the actual

production of alcohol to anaerobic conditions only. The main path of normal respiration thus turns aside before the final alcohol product is reached. Instead, the labile intermediate compounds are completely oxidized to the end products of oxygen respiration.

Blackman in 1928 suggested a schema which is a further modification and expansion of that of Kostyschev. (Fig. 3.) In the first place,

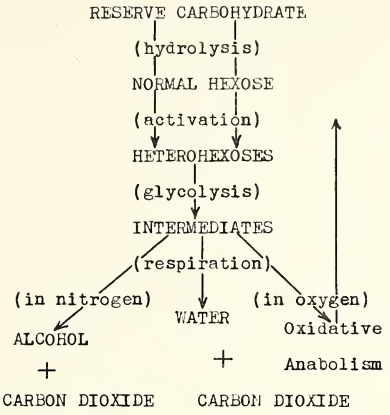

Fig. 3 Blackman's Schema

carbohydrate reserves such as starch or sucrose form the initial substrate. This necessitates a preliminary hydrolytic step to form hexose sugar. Since recent studies on the structure of sugars had described an active gamma-form of hexose, Blackman suggested that an activation step should precede the actual chemical breakdown of the hexose sugar. This cleavage step he labelled "glycolysis." It is anaerobic in nature and corresponds generally to the first step in Kostyschev's schema. Also following Kostyschev's concept, Blackman's schema gives ethyl alcohol and carbon dioxide as the final products of seed-plant respiration in nitrogen, and carbon dioxide and water as final products in oxygen (air).

There is, however, a final additional feature which Blackman has labelled "oxidative anabolism." In this step some of the carbon which might be expected to be released under aerobic conditions as carbon dioxide fails to appear. It is argued that this carbon must therefore be built back into one of the substances preceding, or intermediate in, glycolysis. This addition to the schema was included in an effort to explain the higher rates of carbon-dioxide production obtained with apple fruits in nitrogen compared to those obtained in air.

A different point of view of the respiratory process is emphasized by certain other writers. Let us look at the schema suggested by the Russian physiologist Palladin in 1908. Palladin made boiling water extractions of tissues from many different plants and found that a large proportion of the species studied contained substances which would color red or violet when treated with hydrogen peroxide and peroxidase. These extracted substances he termed "chromogens" and the oxidation products,

"respiration pigments." Palladin considered that these substances play a part in plant respiration as follows: (Fig. 4.) The chromogens could

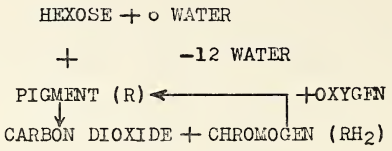

Fig. 4 Palladin's Schema

be oxidized by means of the action of oxidase and free oxygen to form respiratory pigments and water. These respiratory pigments could then bring about the oxidation of the substrates of respiration by removing hydrogen from them anaerobically. The pigments are thus reduced to form the chromogens which can be used again after oxidation in the air.

Here we have emphasis placed upon the anaerobic oxidation of the substrates of respiration. The use of free oxygen is confined to the restoration of the "hydrogen acceptor," as it is called, which in this case is the respiratory pigment. This general viewpoint is in accord with that held today concerning certain phases of cellular oxidations.

Within the past ten years several schemata which involve a series of organic acids and enzyme systems have been suggested for explaining oxidative changes taking place in living cells. One of the best known of these suggestions is that of the citric-acid cycle of Krebs as discussed by Barron (1943). This cycle, in condensed form (Fig. 5), shows

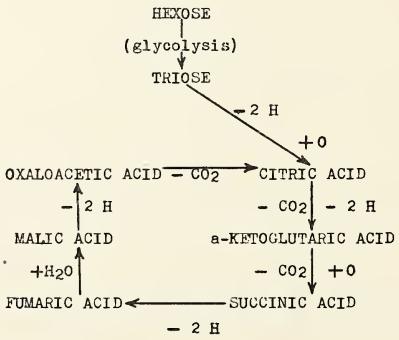

Fig. 5 Krebs Citric Acid Cycle

the oxidation of the glycolytic products of hexose sugar involving the formation of pyruvic acid which is combined with oxalacetic acid and oxidized to citric acid at the beginning of the cycle. Carbon dioxide is split off in the formation of the citric acid and in the two following steps of the condensed cycle.

The remainder of the citric-acid cycle is concerned with the regeneration of the oxalacetic acid to combine with more pyruvic acid formed by the partial oxidation of triose. Coupled with the series of acids which

make up the cycle is a system containing an oxygen activating mechanism including cytochrome and oxidase, plus appropriate dehydrogenase enzymes.

In spite of the fact that the Krebs cycle was based upon pigeon-muscle experiments, efforts have been made by Machlis (1944) and by Henderson and Stauffer (1944) to explain plant respiration upon a similar basis. Excised roots of barley and tomato were treated with oxidase and dehydrogenase inhibitors as well as with respiratory intermediates including fumarate, malate, succinate, and citrate. Studies made upon the responses in respiration to such treatments led these writers to the conclusion that some modified form of the Krebs cycle may function in the respiration of these roots.

Conclusion:

In conclusion it should be pointed out that from simple beginnings in the discovery of facts and the postulation of theories, progress in the study of plant respiration has led to an ever increasing accumulation of facts and to concepts of increasing complexity. When, and if, a complete picture of this fundamental process is eventually gained, we shall doubtless be amazed at the consummate chemist which the minute plant cell is proved to be.

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An Abnormal Fruit Character in Tomato

A. T. Guard, Purdue University

During the summer of 1944 a single tomato plant which bore abnormal fruits occurred in a commercial field of Rutger tomatoes. The fruits of this plant varied from the normal tomato fruit in several ways; namely, there were more carpels; the carpels did not fuse and the fruits were almost completely sterile. Most of the flowers dropped shortly after blooming, but some remained on and the peculiar looking fruits grew to maturity and ripened. In the case of those fruits which ripened there was usually present a considerable amount of proliferated tissue from the center of the axis. When the older part of the fruit was red ripe this proliferated tissue at the tip of the fruit was still green.

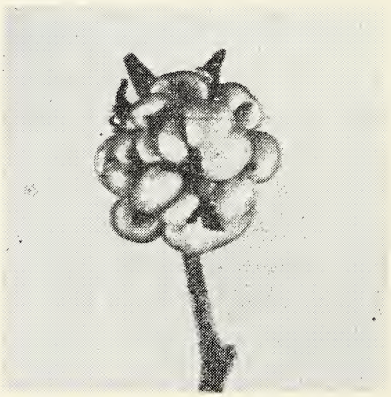

Fig. 1. A partially matured fruit showing the unfused carpels.

This original plant was brought into the greenhouse and propogated vegetatively. One fruit from the plant produced ten seeds which, although undersize, appeared to have embryos in them. These seeds were planted and four germinated. Of the four seedlings, two grew to maturity and produced fruits like those of the parent plant.

Pollen from the original clone was used to make crosses with normal plants of the Rutger variety. This pollen seemed quite normal. F_1 plants from this cross were very vigorous and their fruits were essentially normal except that they were rougher than is characteristic of the Rutger variety.

Selfed seed from these F_1 plants was planted and from this seed 123 F_2 plants were grown to maturity. The flowers of these plants were studied and the plants classified into two groups, those having normal ovaries and those having ovaries showing the abnormal characteristics

of the pollen parent. This distinction was very sharp and no intermediate conditions were observed. Of the 123 plants studied 92 showed normal ovaries and 31 showed ovaries with the unfused carpels.

These data warrant the conclusion that this abnormal type of fruit is a heritable character which is due to a single recessive gene.

Observations of the Growth of an Injured Plant of Dirca Palustris

Fred A. Loew, Huntington College

It is generally thought that an injury to a living organism would decrease its vitality and interfere with its continued growth and development. The following is the story of a five year observation of the relative growth of four plants of *Dirca palustris* (Leatherwood), one of which was injured.

Prior to measuring, the plants were established as follows. In the spring of 1936, three plants of *Dicra Palustris* were taken from a creek bottom of moist alluvial soil in a partly shaded locality, their natural habitat, and placed in an open location of a rather dry silt loam. In the autumn of the following year, 1937, only one of the three plants had survived, and it was somewhat deficient in vigor. In the spring of 1938, the two plants which died were replaced by three others of about the same size taken from the same habitat. During the winter of 1937-38 the surviving specimen of the first replanting was accidentally broken over a couple of inches above the ground. In the spring this plant was straightened and given support to hold the broken parts together until they were repaired. During that summer, 1938, the four plants grew but were not normal as to vigor. The growth of the following summer, 1939, was improved over that of the previous year. The injured plant showed improvement in growth and vigor and the three uninjured ones were in good condition, though not as good as those in their natural habitat. The summer of 1940 showed a noticeable improvement in growth of all four plants. The fracture of the injured plant seemed to have been repaired, only a scar in the bark remaining in sight. All four of the plants, the injured and the uninjured ones, grew well and blossomed. In the autumn of 1941 it was observed that the injured plant had made more growth than any one of the uninjured plants. No measurements were made at this time. The growth of all the plants seemed normal; they all blossomed that season.

At the close of the growing season of the next summer, 1942, measurements were started. Ten of the main branches of each of the four plants were selected as nearly uniform as possible; these were marked with wire rings. At this time measurements of the 1941 growth were made, as well as that of 1942. Total growth measurements were made each succeeding year, including 1945, a total of five years.

The measurements of the total growth in inches for each plant are tabulated below.

Uninjured plants	1941	1942	1943	1944	1945
No. 1S	24.7	24.7	25.2	21.2	15.0
No. 2E	36.0	31.0	24.7	18.5	20.0
No. 3N	27.2	17.2	31.0	22.2	26.0
Average per plant	29.3	24.3	26.9	20.6	20.3
Injured plant	52.7	34.5	27.5	23.2	18.8
Difference	23.4	10.2	00.6	2.6	—1.5

It is fully understood that there are not sufficient data from this one set of observations to make safely any satisfactory deductions as to the causes involved, yet that does not preclude suggestions as to the probable factors. Holeman and Robbins (1939, pp. 39-40), in a discussion of tropisms in relation to the curvature of plant tissue, state, "In the case of tropisms a 'one-sided' external stimulus is responsible for the occurrence as well as the direction of the curvature but the plant itself curves by reason of a different rate of growth on the two sides of the organ." After raising the question as to the cause of the different rate of growth on the two sides of the organ, they say, "It has been demonstrated that growth hormones play an important role in this phenomenon. A hormone is a substance which produced in one part of an organism is moved to another part and there is capable of influencing a specific physiological process."

From Smith, Gilbert, *et al* (1942, p. 66) this statement is quoted, "When the stem, roots or even leaves of some plants are exposed to unusual stimuli such as wounding, as for example when a branch is cut from the stem, the exposed thin-walled cells are stimulated to divide." From these two references we might be warranted in suggesting the following application to the injured *Dirca palustris* plant.

First. When this plant was broken it received an unusual stimulus which caused an unusual accumulation of growth hormones around the fractured tissue which resulted in the formation of an unusual amount of thin-walled growing tissue. The amount of growing tissue decreased each succeeding year as indicated by the table.

Second. When the fractured tissue became repaired there might have been a surplus of growth hormones which stimulated the additional growth. This surplus might have been reduced each succeeding year as the need became less after the repair was made; thus in a few years the difference between the amount of growth between the injured and the uninjured plants would be removed and a balance reached as indicated by the table.

References

Holeman, Richard, and Robbins, Wilfred W.

1939. A textbook of General Botany for colleges and universities.

Smith, Gilbert M.; Gilbert, Edward M.; Evans, Richard I.; Duggar, Benjamine M.

1942. A textbook of General Botany. Fourth Edition.

Indiana Plant Distribution Records, VI. 1945

This is a continuation of the annual reports intended as a supplement to Deam's "Flora of Indiana." The report comprises three sections, viz. "SPECIES," giving new county records with the location of confirming specimens; "NOMENCLATORIAL CHANGES" in which an attempt is made, within the limits and in the spirit of conservative taxonomy, to keep the "Flora" up to date in plant names; "DELETIONS" in which known previous errors of determination are corrected.

Species

Genera are listed in the order given in the "Flora" and species are given in alphabetical order under the genera. Symbols following the counties indicate the herbaria in which confirming specimens have been deposited. Species, varieties or forms new for the state are given in boldface and these, together with name changes, are followed by literature references. Cases of doubt whether a species, newly found within the state, will become a part of the state flora are preceded by an asterick.

The specimens listed below have been collected by the following collectors: Butler University (B): Charles C. Deam, Charles M. Ek, Ray C. Friesner, Ralph Kriebel, Scott McCoy, and John E. Potzger; Deam Herbarium (D): Charles C. Deam, Ray C. Friesner, Ralph Kriebel, and John E. Potzger; Crispus Attucks High School (CA): William H. Rhoades; DePauw University (DP): Ray C. Friesner, Nancy Kreicker, Patricia O'Hair, John E. Potzger, Winona H. Welch, and T. G. Yuncker; Duke University (Du): Ray C. Friesner, R. M. Tryon, Jr.; Goshen College (Go): S. W. Witmer; Gray Herbarium (G): Ray C. Friesner; Huntington College (H): Fred Loew; Indiana University (IU): W. E. Ricker; University of Kansas (Ka): J. A. Holmes; Kriebel Private Herbarium (K): Ralph Kriebel; New York Botanical Garden (NY): Charles C. Deam, Mrs. Joseph Clemens, and Ray C. Friesner; University of Notre Dame (ND): John E. Potzger; University of Pennsylvania (Pa): Charles C. Deam; Purdue University (P): John E. Potzger; U. S. National Arborteum (USNA): Rhodora 47: 58, U. S. National Herbarium (N): John E. Potzger and Scott McCoy.

The committee maintains a card file showing published distribution of each species within the state. Botanical workers needing such information may obtain distribution maps of any species, recorded in the "Flora" or subsequently added in these reports, by requesting same from the secretary of this committee.

Botrychium dissectum, Union (D,B). *B. d.* v. *obliquum*, Lagrange (D), Scott (B). *Cystopteris fragilis* v. *protrusa*, Carroll (B), Vermillion (B). *Dryopteris hexagonoptera*, Orange (B), Union (B). *D. thelypteris* v. *pubescens*, Carroll (B), Huntington (D). *Polystichum*

acrostichoides, Union (B). *P. a.* f. *incisum*, Harrison (D). *Athyrium angustum* v. *rubellum*, Scott (B). *A. pycnorcarpon*, Vermillion (B). *Asplenium cryptolepis*, Harrison (B). *A. platyneuron*, Scott (B). *Equisetum arvense*, Randolph (B). *E. nelsoni*, Clinton (B), La Porte (B). *E. prealtum*, Union (B).

Juniperus virginiana v. *crebra*, Scott (B), Union (B). *Typha latifolia*, Harrison (D). *Najas flexilis*, Harrison (D, B). *Alisma subcordatum*, Orange (D). *Bromus commutatus*, Elkhart (B), Putnam (B), Vermillion (B). *B. inermis*, Elkhart (B). *B. japonicus*, Harrison (D, B), Vermillion (B). *B. purgans*, Vermillion (B). *B. secalinus*, Randolph (B). *B. tectorum*, Randolph (B), Vermillion (B). *Festuca elatior*, Randolph (B). *F. obtusa*, Vermillion (B). *F. ovina*, Elkhart (B), Lagrange (B). *F. rubra*, Lagrange (B).

Glyceria septentrionalis, Vermillion (B). *G. striata*, Randolph (B), Vermillion (B). *Poa annua*, Randolph (B), Starke (B), Steuben (B), Vermillion (B). *P. compressa*, Huntington (H), Vermillion (B). *P. paludigena*, Elkhart (D, B). *P. palustris*, Elkhart (B). *P. pratensis*, Blackford (B), De Kalb (B), Huntington (H), Randolph (B). *Eragrostis cilianensis*, Orange (D), Union (B), Vermillion (B). *E. frankii*, Clinton (B), Harrison (D), Union (B), Wayne (B). *E. pectinacea*, Union (B). *E. spectabilis*, Union (B).

Dactylis glomerata, Elkhart (B), Huntington (H), Randolph (B). *Melica nitens*, Randolph (B). *Triodia flava*, Delaware (B), Jasper (B), Starke (B), Union (B). *Agropyron repens*, Huntington (H), Orange (D). *Elymus villosus*, Carroll (B). *E. virginicus* v. *australis*, Harrison (D). *E. v.* v. *intermedius*, Harrison (D). *Hystrix patula*, Vermillion (B). *Hordeum jubatum*, Randolph (B). *H. pusillum*, Vermillion (B). *Koeleria cristata*, Elkhart (D, B). *Danthonia spicata*, Vermillion (B). *Calamagrostis canadensis*, Vermillion (B). *Agrostis alba*, Blackford (B), Vermillion (B). *A. hyemalis*, Vermillion (B). *A. perennans*, Orange (B), Union (B), Vermillion (B). *Cinna arundinacea*, Orange (B).

Phleum pratense, Elkhart (B), Lagrange (B), Vermillion (B). *Muhlenbergia frondosa*, Clinton (B), Delaware (B), Wayne (B). *M. mexicana*, Carroll (B), Delaware (B), La Porte (B), Starke (B). *M. schreberi*, Orange (B), Randolph (B). *M. sobolifera*, Huntington (D). *M. sylvatica*, Vermillion (B), Crawford (D), Harrison (D). *M. tenuiflora*, Rush (B). *Sporobolus asper*, Jasper (B). *S. clandestinus*, Jasper (B). *S. heterolepis*, Cass (B). *S. neglectus*, Carroll (B), Jasper (B), Union (B). *S. vaginiflorus*, Madison (B), Randolph (B), Union (B). *Stipa avenacea*, Elkhart (B). *A. longispica*, Orange (B). *A. oligantha*, Crawford (D).

Eleusine indica, Clinton (B). *Hierochloë odorata*, Randolph (B). *Bouteloua curtipendula*, Harrison (D, B, K), Vermillion (B). *Leersia oryzoides*, La Porte (B), Orange (B). *L. virginica*, Blackford (B), Orange (D, B). *Digitaria ischaemum*, Orange (B), Union (B). *D. sanguinalis*, Clinton (B), Delaware (B), Orange (B), Vermillion (B). *Leptoloma cognatum*, Clinton (B), Noble (B), Union (B), Vermillion (B).

Paspalum circulare, Jasper (B), Orange (D). *P. pubiflorum* v. *glabrum*, Orange (B).

Panicum addisoni, Elkhart (B). *P. agrostoides*, Crawford (D), Switzerland (K, B). *P. boscii*, Vermillion (B). *P. capillare*, Crawford (D). *P. clandestinum*, Vermillion (B). *P. depauperatum*, Elkhart (B), Noble (B). *P. dichotomiflorum*, Harrison (D), Huntington (D). *P. dichotomum*, Vermillion (B). *P. flexile*, Jasper (B).*P. gattingeri*, Union (B). *P. huachucae*, Vermillion (B). *P. implicatum*, Randolph (B). *P. latifolium*, Vermillion (B). *P. linearifolium* v. *werneri*, Harrison (D, B). P. **longifolium** Torr., Hitchcock, Man. Grasses U. S., p. 679. Collected by J. E. Potzger. Starke (B, D, DP, H, IU, N, ND, P). *P. microcarpon*, Orange (B). *P. oligosanthes*, Elkhart (B, D). *P. philadelphicum*, Orange (B). *P. pseudopubescens*, Elkhart (D, B). *P. stipitatum*, Orange (D, B). *P. tsugetorum*, Elkhart (B).

Echinochola crusgalli, Huntington (H), Orange (D). *Setaria italica*, Jasper (B). *S. lutescens*, Delaware (B), La Porte (B), Orange (D, B), Vermillion (B). *E. viridis*, Huntington (H), La Porte (B). *Andropogon elliottii*, Crawford (D). *A. scoparius*, Randolph (B). *A. virginicus*, Carroll (B), Union (B). *Sorghastrum nutans*, Carroll (B), Delaware (B).

Eleocharis acicularis v. *typica*, Harrison (D). *E. quadrangulata* v. *crassior*, Switzerland (K, D, B). *Carex frankii*, Huntington (H), Orange (D). *C. grayii* v. *hispidula*, Harrison (D). *C. picta*, Jennings (K, D, B). *C. rosea*, Huntington (H). *C. scoparia*, Tippecanoe (B). *C. typhina*, Orange (D). *C. umbellata*, Lagrange (B, D, G, NY, Mi). *Symplocarpus foetidus*, Randolph (B). *Commelina communis*, Vermillion (B). *Tradescantia ohioensis*, Vermillion (B). *Juncus diffusissimus*, Orange (D). *J. marginatus*, Harrison (D), Washington (D). *J. tenuis* f. *anthelatus*, Orange (D). *Luzula multiflorus* v. *bulbosa*, Orange (D).

Melanthium virginicum, Randolph (B). *Allium canadense*, Vermillion (B). *Smilacina racemosa* v. **cylindrata** Fern. Rhodora 40: 406. 1938; Amer. Midland Nat. 33: 644-666. 1945. Bartholomew (D, B), Boone (D), Brown (D), Carroll (D), Clark (D), Crawford (D), Daviess (D), Dearborn (D, B), Decatur (D, B), De Kalb (B), Delaware (D), Dubois (D), Elkhart (D), Fayette (D, B), Fountain (D, B), Franklin (D, B), Fulton (B), Gibson (D), Grant (B), Hancock (D), Hendricks (B), Howard (D, B), Jackson (D, B), Jasper (B), Johnson (D, B), Knox (B), Lagrange (D, B), Lake (D), La Porte (B), Marion (D, B), Marshall (D), Noble (D, B), Ohio (B), Owen (B), Parke (B), Perry (D), Pike (D), Porter (D, B), Posey (D, B), Pulaski (B), Ripley (D), Rush (B), Scott (D), Shelby (B), Spencer (D, B), St. Joseph (B), Sullivan (D), Tippecanoe (B), Vermillion (B), Wabash (B), Warren (D, B), Warrick (D), Washington (D), Wells (B), Whitely (D).

S. r. v. *typica* Fern., Adams (D), Allen (D), Blackford (D), Boone (D), Cass (D), Clinton (D, B), Crawford (B), Elkhart (B), Fulton (D), Grant (D), Greene (D), Huntington (D), Hamilton (D), Harrison (D), Jasper (D), Jay (D), Jefferson (D, B), Jennings (D), Kosciusko

(D), La Porte (D), Lawrence (D), Madison (B), Marion (D, B), Marshall (D), Martin (D), Miami (D, B), Montgomery (D, B), Morgan (D), Newton (D), Ohio (D), Orange (D), Parke (D), Posey (D), Pulaski (D), Putnam (D), Randolph (D, B), Ripley (B), Rush (D, B), Starke (D), Steuben (D), St. Joseph (D), Switzerland (D), Wabash (D), Wells (D), White (D).

Maianthemum canadense v. *interius*, Elkhart (D, B). *Trillium flexipes* f. *walpolei*, Morgan (B), Randolph (B). *T. recurvatum* f. *luteum*, Putnam (DP). *T. sessile* f. *luteum*, Putnam (DP). *Smilax ecirrhata*, Randolph (B). *S. glauca*, Scott (B). *S. hispida*, Scott (B), Union (B), Vermillion (B). *Hypoxis hirsuta*, Randolph (B). *Dioscorea quaternata*, Scott (B). *Iris virginica* v. *shrevei*, Randolph (B). *Cypripedium calcelous* v. *pubescens*, Vermillion (B). *C. reginae*, Elkhart (D, B), Randolph (B). *Orchis spectabilis*, Miami (B).

Populus deltoides, Harrison (D). *Juglans cinerea*, Huntington (H). *J. nigra*, Union (B), Vermillion (B). *Carya cordiformis*, Orange (B), Union (B). *C. laciniosa*, Blackford (B), Carroll (B), Huntington (H), Union (B). *C. ovalis* v. *obcordata*, Wells (D, B). *C. o.* v. *obovalis*, Wells (D, B). *C. tomentosa*, Elkhart (D), Vermillion (B). *Carpinus caroliniana* v. *virginiana*, Carroll (B), Vermillion (B). *Ostrya virginiana*, Vermillion (B). *O. v.* f. *glandulosa* Scott (B), Union (B). *Corylus americana*, Scott (B). *Betula pumila* v. *glandifera*, Elkhart (B). *Alnus rugosa*, Washington (D). *Fagus grandifolia*, Scott (B), Union (B), Vermillion (B). *Quercus alba*, Scott (B). *Q. bicolor*, Carroll (B). *Q. borealis* v. *maxima*, Union (B), Vermillion (B). *Q. macrocarpa*, Carroll (B), Union (B). *Q. muhlenbergii*, Union (B). *Q. palustris*, Orange (B). *Q. velutina*, Scott (B), Vermillion (B).

Ulmus americana f. **alba** (Ait.) Fern. Rhodora 47: 133. 1945. Blackford (B), Carroll (B), Jefferson (B), Orange (B), Scott (B), Union (B), Vermillion (B). *U. rubra* Muhl. Rhodora 47: 203-204. 1945. Carroll (B), Union (B). *U. thomasi*, Carroll (B). *Celtis occidentalis* v. *crassifolia*, Blackford (B), Union (B), Vermillion (B). *Morus alba* v. *tatarica*, Union (B). *M. rubra*, Carroll (B), Orange (B), Scott (B), Union (B), Vermillion (B). *Maclura pomifera*, Union (B). *Humulus americanus*, Clinton (B). *Urtica procera*, Scott (B), Vermillion (B), Washington (B). *Laportea canadensis*, Clinton (B), Crawford (D), Huntington (H), Jasper (B), Starke (B). *Pilea pumila*, Washington (B). *Boehmeria cylindrica*, Orange (B), Vermillion (B). *Parietaria pennsylvanica*, Union (B).

Polygonum neglectum, Vermillion (B). *P. pennsylvanicum* v. *laevigatum*, Orange (B), Vermillion (B). *P. persicaria*, Huntington (H), Union (B). *P. punctatum*, Orange (B), Scott (B), Union (B). *P. scandens*, Blackford (B). *P. virginianum*, Huntington (H). *Chenopodium ambrosioides* ssp. *eu-ambrosioides*, Scott (B). *C. botrys*, Union (B). *Atriplex patula* v. *littoralis*, Lagrange (D). *Salsola pestifer*, Union (B). *Amaranthus albus* L. Rhodora 47: 139-140. 1945. Harrison (D). *Acnida tamariscina*, Union (B). *Phytolacca americana*, Union (B). *Mollugo*

verticillata, Bartholomew (B), Union (B), Vermillion (B). *Cerastium vulgatum* v. *hirsutum* f. *glandulosum,* Blackford (B). *Silene cserei,* Brown (B). *Lychnis alba,* Tippecanoe (B). *Saponaria officinalis,* Clinton (B).

Nuphar advena, Washington (D). *Aquilegia canadensis,* Randolph (B). *Anemone canadensis,* Delaware (B). *Hepatica americana,* Noble (B). *Clematis virginiana,* Harrison (D), Orange (D, B). *Ranunculus abortivus,* Huntington (H). *R. flabellaris,* Henry (B). *R. sceleratus,* Jasper (B). *Thalictrum dasycarpum,* Harrison (D). *Menispermum canadense,* Blackford (B), Scott (B), Vermillion (B). **Magnolia tripetala** L. Gray Man. 7ed p. 409. Collected by Charles C. Deam. Crawford (D, B, C, G, K, NY, O, SW). *Liriodendron tulipifera,* Scott (B), Union (B). *Asimina triloba,* Blackford (B), Carroll (B), Orange (B), Union (B). *Sassafras albidum,* Carroll (B), Noble (B), Scott (B), Vermillion (B). *S. a.* v. *molle,* Union (B). *Lindera benzoin,* Scott (B).

Lepidium campestre, Owen (B). *L. virginicum* v. *typicum,* Blackford (B), Vermillion (B). *Thlaspi arvense,* Randolph (B). *Sisymbrium altissimum,* Brown (B), Vermillion (B). *S. officinale* v. *leiocarpum,* Vermillion (B). *Rorippa islandica* v. *microcarpa,* Delaware (B). *R. sylvestris,* Vermillion (B). *Armoracia rusticana,* Huntington (H). *Cardamine douglassii,* Randolph (B). *Capsella bursa-pastoris,* Huntington (H). *Descurainea pinnata* v. *brachycarpa,* Cass (B). *Penthorum sedioides,* Union (B). *Heuchera americana* v. *brevipetala,* Randolph (B). *H. richardsonii* v. *grayana,* Noble (B). *Hydrangea arborescens,* Vermillion (B). *Grossularia hirtella,* Elkhart (B). *Hamamelis virginiana,* Blackford (B). *Platanus occidentalis,* Carroll (B), Clinton (B).

Crataegus mollis, Huntington (H). **Rubus nescius** Bailey. Gentes Herbarum 5: 808. 1945. Harrison (D). Collected by Charles C. Deam. *R. occidentalis,* Blackford (B), Union (B). *Fragaria virginiana,* Huntington (H). *F. v.* v. *illinoensis,* Jefferson (B). *Potentilla recta,* Blackford (B), Carroll (B), Huntington (H). *Geum canadense,* Vermillion (B). *G. virginianum,* Vermillion (B). *Filipendula rubra,* Delaware (B). *Agrimonia parviflora,* Huntington (H), Orange (B). *Rosa palustris,* Randolph (B). *Prunus lanata,* Harrison (B). *P. serotina,* Scott (B), Union (B).

Cercis canadensis, Randolph (B). *Cassia hebecarpa,* Crawford (B). *Gleditsia triacanthos,* Carroll (B), Union (B). *G. t.* f. *inermis,* Wells (D). *Medicago lupulina,* Blackford (B), Vermillion (B). *Melilotus alba,* Blackford (B), Vermillion (B). *M. officinalis,* Vermillion (B). *Trifolium hybridum* v. *elegans,* Blackford (B), Vermillion (B). *T. pratense,* Vermillion (B). *T. procumbens,* Blackford (B). *Petalostemum candidum,* Vermillion (B). *Robinia pseudo-acacia,* Union (B). *Stylosanthes biflora,* Crawford (D). *Desmodium bracteosum,* Crawford (D), Huntington (D, H), Union (B). *D. ciliare,* Harrison (D). *D. glutinosum,* Union (B). *D. illinoense,* Vermillion (B). *D. paniculatum,* Huntington (H). *D. p.* v. *pubens,* Crawford (D), Harrison (D). *D. pauciflorum,* Crawford (D),

Orange (D). *D. rotundifolium,* Huntington (D). *D. sessilifolium,* Harrison (D). *D. viridiflorum,* Crawford (D). *Lespedeza violacea,* Crawford (D), Huntington (D, H). *Lathyrus palustris* v. *linearifolius,* Elkhart (B), Randolph (B). *L. venosus* v. *intonsus,* Noble (B). *Clitoria mariana,* Harrison (D, B). *Amphicarpa bracteata* v. *comosa,* Union (B). *Apios americana,* Harrison (B). *Phaseolus polystachios* v. *typica,* Crawford (D, B). *Strophostyles helveola,* Huntington (H), Washington (D).

Geranium carolinianum v. *confertiflorum,* Vermillion (B). *G. maculatum,* Henry (B). *G. pusillum,* Lagrange (D, B). *Oxalis europaea,* Huntington (H). *O. e.* f. *cymosa,* Blackford (B), Orange (B). *O. e.* f. *villicaulis,* Jasper (B). *O. stricta,* Union (B). *O. s.* v. *piletocarpa,* Vermillion (B). *Linum medium* v. *texanum,* Crawford (D, B), Harrison (D, B). *L. striatum,* Elkhart (B). *Zanthoxylum americanum,* Union (B). *Acalypha rhomboidea,* Orange (B), Scott (B). *Euphorbia commutata,* Randolph (B). *E. cyparissias,* Harrison (D). *E. dentata,* Starke (B), Union (B). *E. heterophylla,* Carroll (B). *E. maculata,* Orange (B), Union (B). *E. supina,* Union (B). *Rhus copallina* v. *latifolia,* Orange (D). *R. glabra,* Union (B). *R. radicans,* Union (B). *R. r.* v. *littoralis,* Crawford (D). *R. vernix,* Carroll (B), Huntington (D, H). *Euonymus americanus,* Orange (B). *Celastrus scandens,* Union (B).

Acer nigrum, Carroll (B), Union (B). *A. rubrum,* Blackford (B), Orange (B). *A. saccharum,* Scott (B), Union (B). *A. s.* v. *rugelii,* Lagrange (B). *Impatiens biflora,* Orange (B). *Rhamnus lanceolata,* Randolph (B). *Vitis vulpina,* Vermillion (B). *Parthenocissus quinquefolia,* Blackford (B). *P. q.* v. *hirsuta,* Union (B). *Tilia heterophylla,* Franklin (B). *Abutilon theophrasti,* Huntington (H). **Sphaeralcea remota** (Greene) Fern. Gray Man. 7ed. p. 566. Collected by S. W. Witmer. Elkhart (B, D, G, Go, NY, SW). *Sida spinosa,* Huntington (H), Washington (D). *Hypericum mutlium,* Orange (D, B), Randolph (B), Vermillion (B). *Lechea minor,* Newton (D, B). *Viola cucullata,* Elkhart (D, B).

Rotala ramosior v. *typica,* Harrison (D). *Ammania coccinea,* Harrison (D). *Rhexia virginica,* Harrison (D). *Ludwigia alternifolia,* Orange (B). *L. palustris* v. *americana,* Orange (D). *L. polycarpa,* Orange (D). *Epilobium coloratum,* Huntington (D, H). *Oenothera pycnocarpa,* Crawford (D), Huntington (H), Union (B). *Circaea quadrisulcata* v. *canadensis,* Vermillion (B). *Aralia spinosa,* Bartholomew (B). *Panax quinquefolius,* Noble (B). *Sanicula canadensis* v. *grandis,* Blackford (B), Scott (B). *S. c.* v. *typica,* Blackford (B), Scott (B), Vermillion (B), Washington (B). *Chaerophyllum procumbens,* Owen (B). *Osmorhiza longistylis,* Randolph (B). *Cicuta maculata,* Crawford (D), Delaware (B). *Sium sauve,* Carroll (B). *Thaspium barbinode,* Randolph (B). *T. trifoliatum v. flavum,* Blackford (B), Carroll (B). *Angelica purpurea,* Delaware (B). *Oxypolis rigidior,* Carroll (B). *Pastinaca sativa,* Vermillion (B). *Daucus carota,* Orange (D), Vermillion (B).

Nyssa sylvatica v. *caroliniana*, Bartholomew (B), Union (B). *N. s.* v. *typica*, Newton (D), Orange (B), Scott (B), Switzerland (K, B). *Cornus drummondii*, Clinton (B), Harrison (B). *C. femina*, Orange (B), Washington (D, B). *C. florida*, Union (B). *C. stolonifera*, Huntington (D), *Samolus parviflorus*, Orange (B). *Lysimachia ciliata*, Harrison (D), Randolph (B), Union (B). *L. nummularia*, Elkhart (B). *Dodecatheon meadia*, Randolph (B). *Fraxinus americana*, Blackford (B), Orange (B), Scott (B), Union (B). *F. lanceolata*, Carroll (B). *F. nigra*, Carroll (B). *F. quadrangulata*, Carroll (B), Union (B). *Gentiana flavida*, Harrison (D, K, B). *G. procera*, Huntington (D). ***Nymphoides peltatum** (S. P. Gmel.) Britten & Rendle, Gray Man. 7ed. p. 661. Collected by W. E. Ricker. Marshall (IU).

Acerates viridiflora, Noble (B). *Asclepias incarnata*, Vermillion (B). *A. syriaca*, Washington (B). *A. tuberosa* ssp. **interior** Woodson. Missouri Bot. Gard. Ann. 31: 368-369. 1944. Harrison (D, B), Kosciusko (B), Vermillion (B). *Ampelamus albidus*, Orange (B). *Gonolobus gonocarpos*, Harrison (B). *Cuscuta cephalanthi*, Huntington (D). *Ipomoea hederacea*, Union (B). *I. pandurata* v. *rubescens*, Harrison (D), Vermillion (B). *Phlox amplifolia*, Vermillion (B). *P. maculata*, Crawford (B). *P. paniculata*, Clinton (B), Huntington (H). *Hydrophyllum canedense*, Vermillion (B). *Hackelia virginiana*, Huntington (H). *Verbena bracteata*, La Porte (B), Madison (B), Warren (Ka.). X *V. perriana* Moldenke, Johnson (CA). *V. simplex*, Jay (B). *V. urticaefolia*, Vermillion (B).

Teucrium canadense, Elkhart (B). *T. c.* v. *virginicum*, Blackford (B), Vermillion (B). *T. occidentale* v. *boreale*, Vermillion (B). *Scutellaria nervosa* v. **calvifolia** Fern., Rhodora 47: 174. 1945. Adams (D), Allen (D), Bartholomew (D), Clark (D), Daviess (D), DeKalb (B), Gibson (D), Greene (D), Harrison (D), Jackson (D, B, G), Jennings (D), Knox (D), Lawrence (D), Monroe (D,) Posey (D, B), Vanderburgh (D), Warrick (D), Washington (D), Wells (D). *S. n.* v. *typica*, Crawford (D), Dearborn (D), Dubois (D), Orange (D), Perry (D), Pike (D), Spencer (D, B), Switzerland (D), Warren (D). *S. ovata* v. *versicolor*, Vermillion (B). *Agastache scrophularifolia*, Crawford (D), Vermillion (B). *Nepeta cataria*, Huntington (H), Vermillion (B). ***Dracocephalum parviflorum** Nutt., Gray Man. 7ed., p. 697. Collected by Winona H. Welch. Putnam (DP). *Prunella vulgaris* v. *lanceolata*, Huntington (H). *Physostegia speciosa*, Harrison (D).

Stachys tenuifolia v. *hispida*, Union (B). *S. t.* v. *typica*, Orange (D), Vermillion (B). *Monarda clinopodia*, Union (B). *Blephilia hirsuta*, Crawford (D), Scott (B). *Hedeoma hispida*, Tippecanoe (B). *Pycnanthemum flexusoum*, Scott (B). *P. incanum*, Harrison (D). *P. pilosum*, Vermillion (B). *P. virginianum*, Huntington (H). *Lycopus americanus*, Huntington (H). *Mentha arvensis*, Huntington (H). *M. piperita*, Crawford (D). *M. spicata*, Union (B). *Collinsonia canadensis*, Union (B), Washington (D). *Lycium halimifolium*, Carroll (B). *Physalis ambigua*, Delaware (B). *P. heterophylla*, Huntington (H). *P. pubescens*, Harrison (D, B). *P. subglabrata*, Huntington (H), Union (B). *Solanum caro-*

linense, Blackford (B), Carroll (B), Huntington (H), Orange (B), *S. dulcamara*, Huntington (H). *S. nigrum*, Huntington (H). *Datura stramonium*, Harrison (D), Union (B).

Verbascum thapsus, Blackford (B). *Linaria canadensis*, Lagrange (B). *Chaenorrhinum minus*, Blackford (B), Tippecanoe (B). *Scrophularia marilandica*, Vermillion (B). *Chelone glabra* v. *linifolia*, Huntington (H). *C. g.* v. *tomentosa*, Huntington (D). **Penstemon grandiflorus** Nutt., Rydb. Fl. Prairies & Plains, p. 713. Collected by Charles C. Deam, Ray C. Friesner, John E. Potzger and John Seybert. Elkhart (D, B, G). *Mimulus alatus*, Orange (D, B). *M. ringens*, Tippecanoe (B), Vermillion (B). *Leucospora multifida*, Orange (D). *Lindernia anagallidea*, Orange (D). *L. dubia* v. *riparia*, Orange (D), Washington (D). *Veronica peregrina* v. *typica*, Huntington (H). *Veronicastrum virginicum*, Vermillion (B). *Besseya bullii*, Lagrange (B). *Gerardia tenuifolia* v. *parviflora*, Vermillion (B). *Pedicularis lanceolata*, Huntington (D). *Campsis radicans*, Huntington (H). *Orobanche ludoviciana* v. *genuina*, Harrison (D).

Ruellia caroliniensis v. **cheloniformis** Fern., Rhodora 47: 80-81. 1945., Crawford (D, B, NY), Jefferson (NY), Warrick (D). *R. c.* v. **dentata** (Nees) Fern., Rhodora 47: 83. 1945., Floyd (D). *R. c.* v. **membranacea** Fern., Rhodora 47: 75-78. 1945., Clark (D), Spencer (D), Washington (D). *R. c.* v. **nanella** Fern., Rhodora 47: 79-80. 1945., Clark (D), Floyd (D, B). *R. c.* v. **salicina** Fern., Rhodora 47: 81-82. Clark (H). *R. c.* v. **semicalva** Fern., Rhodora 47: 73-75. 1945., Crawford (D), Dubois (D), Floyd (D, B), Perry (D). *R. c.* v. *typica* Fern., Rhodora 47: 71-73. 1945., Crawford (B), Orange (D), Washington (D). *R.* **humilis** v. **calvescens** Fern., Rhodora 47: 60. 1945., Crawford (D, Pa). *R.* **h.** v. **expansa** Fern., Rhodora 47: 58. 1945, Gibson (D), La Porte (D), Montgomery (N), Tippecanoe (B, USNA), Warren (D), Vermillion (B). *R.* **h.** v. **frondosa** Fern., Rhodora 47: 54. 1945, Benton (D, B), Cass (D, B), Clinton (B), Daviess (D), Elkhart (D), Floyd (B), Gibson (D), Greene (D), Hancock (B), Harrison (D, B, Du, NY), Jasper (D), Knox (B), Lagrange (D), Lawrence (D), Madison (D), Marion (D, B, G), Miami (D, B), Newton (D, B), Posey (D), Pulaski (D), Tippecanoe (D, B), Vermillion (D), Warren (D, NY), Wells (D), White (D, B). *R.* **h.** v. **typica** Fern., Rhodora 47: 51. 1945, Clinton (B), Crawford (D), Floyd (D, NY), Hancock (B), Harrison (D, B), Knox (D), Orange (B), Posey (D), Spencer (D), St. Joseph (NY), Sullivan (D), Warren (D, Du). *R.* **h.** v. **typica** f. **grisea**, Harrison (B). *R. strepens*, Blackford (B), Cass (B), Ohio (B), Switzerland (B). *R. s.* f. *cleistantha*, Henry (B), Howard (D, B), Jennings (D), Knox (B), Montgomery (B).

Dianthera americana, Crawford (D). *Plantago aristata*, Huntington (H), Orange (B), Vermillion (B). *P. lanceolata*, Vermillion (B). *P. purshii*, Elkhart (D, B). *P. virginica*, Lagrange (B). *Houstonia longifolia*, Vermillion (B). *Cephalanthus occidentalis*, Orange (B), Vermillion (B). *Galium asprellum*, Delaware (B), Huntington (H), Randolph (B). *G. boreale* v. *intermedium*, Noble (B). *G. circaezans* v. *hypomalacum*, Orange (D). *G. c.* v. *typicum*, Scott (B). *G. concinnum*, Scott

(B), Union (B). *Sambucus canadensis,* Union (B). *Viburnum acerifolium,* Scott (B). *V. lentago,* Randolph (B). *Triosteum perfoliatum,* Cass (B), Huntington (D). *Lonicera japonica,* Washington (D). *L. xylosteum,* Elkhart (D, B). *Specularia perfoliata,* Vermillion (B). *Lobelia cardinalis,* Harrison (D, B). *L. inflata,* Orange (D, B), Scott (B), Union (B), Vermillion (B). *L. puberula,* Switzerland (K, B). *L. siphilitica,* Orange (B), Union (B).

Vernonia altissima, Orange (B). *V. missurica,* Crawford (D, B). *Eupatorium altissimum,* Huntington (D), Jasper (B). *E. perfoliatum,* Henry (B), Orange (D, B). *E. purpureum,* Orange (B). *E. rugosum,* Orange (B). *E. serotinum,* Orange (B), Scott (B), Union (B). *Solidago altissima,* Clinton (B), Vermillion (B). *S. caesia,* Union (B). *S. canadensis* v. *gilvocanescens,* Henry (B). *S. gigantea,* Harrison (B), Jasper (B). *S. g.* v. *leiophylla,* Crawford (D), Harrison (D, B), Union (B). *S. graminifolia* v. *media,* Noble (B). *S. g.* v. *nuttallii,* Carroll (B), Union (B). *S. juncea,* Orange (D). *S. latifolia,* Union (B). *S. missouriensis* v. *fasciculata* Holz, Vermillion (B). *S. nemoralis,* Noble (B), Union (B). *S. ohioensis,* Carroll (B), Randolph (D, B). *S. rigida,* Vermillion (B). *S. rugosa,* Switzerland (K, D, B). *S. uniligulata,* Huntington (D).

Aster ericodies, Lagrange (D), Newton (D). *A. e.* v. *prostratus,* Lagrange (D). *A. lucidulus,* Huntington (D). *A. oblongifolius* v. *angustatus,* Harrison (D, B.) *A. pilosus,* Orange (B), Scott (B), Union (B). *A. praealtus,* Huntington (D, B). *A. p.* v. *angustior,* Newton (D). *Erigeron annuus,* Blackford (B), Vermillion (B). *E. canadensis,* Orange (B), Vermillion (B). *Silphium integrifolium,* Randolph (B). *S. i.* v. *deamii,* Tippeacanoe (B). *S. laciniatum,* Vermillion (B). *Ambrosia elatior,* Henry (B), Union (B). *A. trifida,* Henry (B). *Xanthium pennsylvanicum,* Union (B). *Eclipta prostratus* (L.) L., Rhodora 47: 196., Orange (D). *Rudbeckia deamii,* Crawford (D, B, K), Harrison (D, B, K), Huntington (D), Orange (D), Union (D, B). *R. fulgida,* Crawford (D, B). *R. hirta,* Carroll (B), Orange (D), Vermillion (B). *R. laciniata,* Washington (D). *R. triloba,* Switzerland (K, D, B). *Actinomeris alternifolia,* Union (B). *Coreopsis tripteris,* Huntington (H).

Bidens aristosa v. *mutica,* Jasper (B), Scott (D, B). *B. bipinnata,* Orange (B). *B. comosa,* Huntington (D, H), Union (B). *B. vulgata,* Huntington (D). *Anthemis cotula,* Blackford (B), Huntington (H), Vermillion (B). *Achillea millefolium,* Vermillion (B). *Chrysanthemum leucanthemum* v. *pinnatfidum,* Vermillion (B). *Artemisia annua,* Harrison (D), Union (B). *Erechtites hieracifolia,* Crawford (B), Orange (B). *Cacalia atriplicifolia,* Union (B). *Cirsium arvense,* Blackford (B). *C. discolor,* Henry (B), Union (B). *C. muticum,* Carroll (B). *Cichorium intybus,* Huntington (H), Union (B), *Tragopogon pratensis,* Brown (B), Madison (B), Starke (B). *Lactuca biennis,* Crawford (D), Huntington (H), Scott (B). *L. canadensis* v. *longifolia* (Michx.) Farwell, Rhodora 40: 480, Vermillion (B). *L. scariola,* Clinton (B), Union (B). *L. s.* v. *integrata,* Jasper (B). *L. villosa,* Harrison (D, B). *Prenanthes altissima,* Noble (B). *P. aspera,* Harrison (B). *P. gronovii,* Orange (D).

Deletions

The following deletion should be made from the State Flora Catalog: *Helianthus annuus,* drop Lake county.

Additional Species Added to the Deam Herbarium

The following species previously reported in other herbaria for certain counties have been added to the Deam herbarium since the last report.

Botrychium dissectum v. *obliquum,* Marion. *Sagittaria brevirostra,* Harrison. *Elymus canadensis,* Huntington. *E. virginicus,* Huntington. *Cinna arundinacea,* Huntington. *Panicum anceps,* Harrison. *Sorghastrum nutans,* Huntington. *Salix discolor,* Huntington. *Carya cordiformis,* Huntington. *Quercus borealis* v. *maxima,* Huntington. *Q. imbricaria,* Harrison. *Cannabis sativa,* Lagrange. *Mollugo verticillata,* Washington. *Rorippa sessiliflora,* Harrison. *Penthorum sedioides,* Harrison. *Parnassia glauca,* Huntington. *Liquidambar styraciflua,* Harrison. *Filipendula rubra,* Huntington. *Tephrosia virginiana* v. *holosericea,* Harrison. *Amphicarpa bracteata,* Huntington. *Oxypolis rigidior,* Huntington.

Stachys tenuifolia, Harrison. *Lindernia dubia* v. *riparia,* Harrison. *Dasistoma macrophylla,* Harrison. *Epifagus virginiana,* Marion. *Lobelia siphilitica,* Washington. *Eupatorium perfoliatum,* Huntington. *E. rugosum,* Huntington. *Solidago caesia,* Huntington, Marion. *S. graminifolia* v. *nuttallii,* Huntington, *S. riddellii,* Huntington. *Aster novae-angliae,* Huntington. *A. pilosus,* Lagrange. *Helianthus tuberosus,* Huntington. *Bidens frondosa,* Huntington. *Helenium autumnale,* Huntington. *Cirsium muticum,* Huntington.

Nomenclatorial Changes

The following changes in names of Indiana plants are considered by the committee to be likely of acceptance by taxonomists generally. Other name changes have recently appeared in the literature but are temporarily withheld from this list awaiting further evidence of their merit and likelihood of general acceptance.

Pteretis nodulosa (Michx.) Nieuwland to
P. pennsylvanica (Willd.) Fern.
Rhodora 47: 123. 1945

P. nodulosa f. pubescens (Terry) Fern. to
P. pennsylvanica f. **pubescens** (Terry) Fern.
Rhodora 47: 124. 1945

Dryopteris thelypteris v. pubescens (Lawson) Prince to
D. thelypteris v. **pubescens** (Lawson) Nakai
Bot. Mag. Tokyo 45: 97. 1931.

Festuca obtusa Spreng. to
F. obtusa Biehler
Rhodora 47: 199. 1945

Festuca octoflora Walt. to
Vulpia octoflora (Walt.) Rydb.
Rhodora 47: 107. 1945

Festuca octoflora v. tenella (Willd.) Fern. to
Vulpia octoflora v. tenella (Willd.) Fern.
Rhodora 47: 107. 1945

Agropyron trachycaulum (Link) Malte
in Flora as synonymn of
A. subsecundum (Link) Hitchc. change to syn. of
A. **pauciflorum** (Schwein.) Hitchc.
Hitchcock, Man. Grasses, p. 775

Sporobolus clandestinus (Spreng.) Hitchc. to
S. **clandestinus** (Biehler) Hitchc.
Rhodora 47: 198. 1945

Cyperus densicaespitosus Mattf. & Kukenth.
(Kyllingia pumila of "Flora") to
C. tenuifolius (Steud.) Dandy
Rhodora 47: 113. 1945

Scirpus eriophorum Michx. to
S. rubricosus Fern.
Rhodora 47: 124. 1945

Juncus dudleyi Wieg. to
J. tenuis v. dudleyi (Wieg). Hermann
Jour. Arnold Arboret. 25: 56. 1944

Juncus macer S. F. Gray to
J. tenuis Willd.
Rhodora 47: 117. 1945

Juncus macer f. anthelatus (Wieg.) Hermann to
J. tenuis f. anthelatus (Wieg.) Hermann
Rhodora 47: 117-123. 1945
Castanea 10: 23. 1945

Juncus macer f. discretiflorus Hermann to
J. tenuis f. discretiflorus (Hermann) Fern.
Rhodora 47: 123. 1945

Juncus macer f. williamsii (Fern.) Hermann to
J. tenuis f. williamsii (Fern.) Hermann
Rhodora 47: 117-123. 1945
Castanea 10: 23. 1945

Populus deltoides Michx. to
P. deltoides Marsh.
Rehder, Trees and Shrubs, 2ed. p. 81, 1940

Ulmus americana L. to
U. americana f. **alba** (Ait.) Fern.
U. americana f. **intercedens** Fern.
U. americana f. **laevior** Fern.
U. americana f. **pendula** Fern.
Rhodora 47: 132. 1945

Ulmus fulva Michx. to
U. rubra Muhl.
Rhodora 47: 203. 1945

Rumex brittanica L. to
R. orbiculatus Gray
Rhodora 47: 133-137. 1945

Amaranthus graecizans L. to
A. albus L.
Rhodora 47: 139-140. 1945

Amaranthus bliotoides S. Wats. to
A. graecizans L.
Rhodora 47: 139-140. 1945

Sassafras Nees to
Sassafras Trew.
Amer. Midland Nat. 33: 500. 1945

Barbarea vulgaris v. arcuata (J. & C.) Fries.
(Indiana Plt. Distr. Record IV 1943) to
B. vulgaris v. **arcuata** (J. & C. Presl) Fries.
Rhodora 45: 304. 1943

Amorpha canescens Nutt. to
A. canescens Pursh
Pursh Fl. Amer. Sept. 2: 467. 1816

Rhus copallina L. to
R. copallina v. **latifolia** DC.
DC. Mon. 4: 384. 1883
Rhodora 37: 167-168. 1935

Rhus glabra v. borealis Britt. to
X R. borealis Greene
Amer. Midland Nat. 33: 498. 1945

Rhus pulvinata Greene to
X R. borealis Greene
Amer. Midland Nat. 33: 498-499. 1945

Rhus typhina L. to
R. typhina Torner
Amer. Midland Nat. 33: 499-500. 1945
Missouri Bot. Gard. Ann. 24: 326. 1937

Evonymus L. to
Euonymus L.
Amer. Midland Nat. 33: 511. 1945

Napaea dioica L. to
N. dioica v. **stellata** Fassett
Torreya 42: 179. 1943

Epilobium coloratum Muhl. to
E. coloratum Biehler
Rhodora 47: 199. 1945

Epilobium densus Raf.
(E. rosmarinifolium Pursh of Indiana Plt. Distr. Record V. 1944) to
E. leptophyllum Raf.
Rhodora 46: 382. 1944

Panax quinquefolium L. to
P. quinquefolius L.
North Amer. Flora 28B: 9. 1944

Panax trifolium L. to
P. trifolius L.
North Amer. Flora 28B: 10. 1944

Cornus stricta Lam. to
C. femina Willd.
Rhodora 47: 101, 168. 1945

Isanthus brachiatus (L.) BSP. to
Trichostema brachiatus L.
Brittonia 5: 289-291. 1945

Scutellaria incana Spreng. to
S. incana Biehler
Rhodora 47: 199. 1945

Scutellaria leonardi Epling to
S. parvula v. **leonardi** (Epling) Fern.
Rhodora 47: 172. 1945

Scutellaria ovalifolia Pers.
(S. ovalifolia v. hirsuta (Short) Fern. Indiana Plant Distr. Record IV. 1943) to
S. elliptica v. **hirsuta** (Short) Fern.
Rhodora 47: 201. 1945

Scutellaria nervosa Pursh to
S. nervosa v. calvifolia Fern. and
S. nervosa v. typica Fern.
Rhodora 47: 174. 1945

Monarda bradburiana Beck to
M. russeliana Nutt.
Rhodora 46: 491. 1945

Ruellia caroliniensis (Walt.) Steud. and
R. caroliniensis v. parviflora (Nees) Blake to
R. caroliniensis v. cheloniformis Fern.
v. dentata (Nees) Fern.
v. membranacea Fern.
v. nanella Fern.
v. semicalva Fern.
v. typica Fern.
R. **humilis v. calvescens** Ferns.
v. expansa Fern.
v. frondosa Fern.
v. typica Fern.
Rhodora 47: 1-38, 47-63, 69-90. 1945

Solidago glaberrima Martens to
S. missouriensis v. fasciculata Holz,
Amer. Midland Nat. 33: 250. 1945
U. S. Natl. Herb. Contr. 1: 208. 1892

Solidago graminifolia (L.) Salisb. to
S. graminifolia v. typica Rosendahl & Cronquist
Amer. Midland Nat. 33: 253. 1945

Solidago hispida Muhl. to
S. hispida v. typica Rosendahl & Cronquist
Amer. Midland Nat. 33: 248. 1945

Solidago nemoralis Ait. to
S. nemoralis v. typica Rosendahl & Cronquist
Amer. Midland Nat. 33: 249. 1945

Solidago nemoralis v. longipetiolata Palmer & Steyermark to
S. nemoralis v. decemflora (DC.) Fern.
Amer. Midland Nat. 33: 249. 1945
Rhodora 38: 226. 1936

Solidago speciosa Nutt. to
S. speciosa v. typica Rosendahl & Cronquist
Amer. Midland Nat. 33: 248. 1945

Antennaria plantaginifolia (L.) Richards to
A. plantaginifolia (L.) Hook.
Rhodora 47: 240. 1945

Eclipta alba (L.) Hassk. to
E. prostratus (L.) L.
Rhodora 47: 196-197. 1945

Artemisia gnaphalodes Nutt. to
A. ludoviciana v. latifolia (Bess.) T. & G.
Rhodora 47: 252-253. 1945

Lactuca canadensis v. typica Wieg. to
L. canadensis v. longifolia (Michx.) Farwell
Rhodora 40: 480-481. 1938

Lactuca canadensis v. integrifolia (Bigel.) Gray to
L. canadensis L.
Rhodora 40: 480-481. 1938

Lactuca campestris Greene to
L. ludoviciana f. campestris (Greene) Fern.
Rhodora 40: 481. 1938

State Flora Committee:
CHARLES C. DEAM, *Chairman*
RALPH KRIEBEL
T. G. YUNCKER
RAY C. FRIESNER, *Secretary*

CHEMISTRY

Chairman: C.W. Holl, Manchester College

Professor Ed F. Degering, Purdue University, was elected chairman of the section for 1946.

Synthesis and Reactions of Ketenes*

William A. Allen with Ed F. Degering, Purdue University

A recent study by Gwynn and Degering[1] has shown, for the first time, that many ketones react with ketene in the presence of concentrated sulfuric acid, and in each case the product was found to be the acetate of the enol form of the specific ketone employed. These workers studied the reaction of ketene with many ketones, and made a very detailed investigation of the reaction of ketene with acetone.

The subject of the present investigation is a study of the reaction of ketene with 2-butanone, using sulfuric acid as a catalyst. Optimum conditions for this condensation are presented.

Experimental

Materials Used. The acetone used for the generation of the ketene was obtained from Carbide and Carbon Chemicals Corporation and was over 99 per cent pure.

The methyl ethyl ketone used for the condensations with ketene was supplied by the Shell Chemical Company and had a boiling range of 79°C. to 80.5°C. This material was not subjected to further purification.

The sulfuric acid, used exclusively as a catalyst in this work, was the technical grade (66° Baume in every case), and was obtained from various sources.

Pyrolysis and Condensation. The ketene generator was constructed substantially as described by Hurd[2] and modified by Gwynn[1]. In order to remove the unreacted acetone from the gaseous mixture, the pyrolytic products were conducted first through two water-cooled condensers, and then through two cold traps, the first of which was maintained at 0° C. and the second at —35°C. to —40°C. The resultant, substantially acetone-free, gas was then run into the material with which the desired reaction was to be effected. This introduction was facilitated by means of a small inlet tube which directed the entering gases into the blades of a rapidly revolving stirrer which served to disperse the material into

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* Based upon a thesis submitted by William A. Allen to the faculty of Purdue University in partial fulfillment of the requirements for the Degree of Master of Science, May, 1942.

[1] Gwynn, B. H. and Degering, Ed. F., Condensation Products of Ketene with Ketones, J. Am. Chem. Soc., **64**, 2216 (1942).

[2] Hurd, J. Org. Chem., **5**, 122 (1940).

minute bubbles. The reaction tube was raised to the desired temperature by means of an externally heated oil-bath. An expansion chamber surrounded by an ice-bath was placed in a convenient position to return volatile liquids to the reaction chamber. The output of the generator was approximately 0.25 mole of ketene per hour. All analyses of products were made on a modified Podbielniak-type fractionating column, and the 2-buten-2-yl acetate obtained in this manner checked with the constants previously reported.[1]

Discussion

The reaction of ketene with 2-butanone was investigated for the purpose of determining optimum conditions for this condensation. The product, 2-buten-2-yl acetate, was previously prepared by Gwynn and Degering,[1] who condensed ketene with methyl ethyl ketone in the presence of sulfuric acid as a catalyst, and obtained a product which they

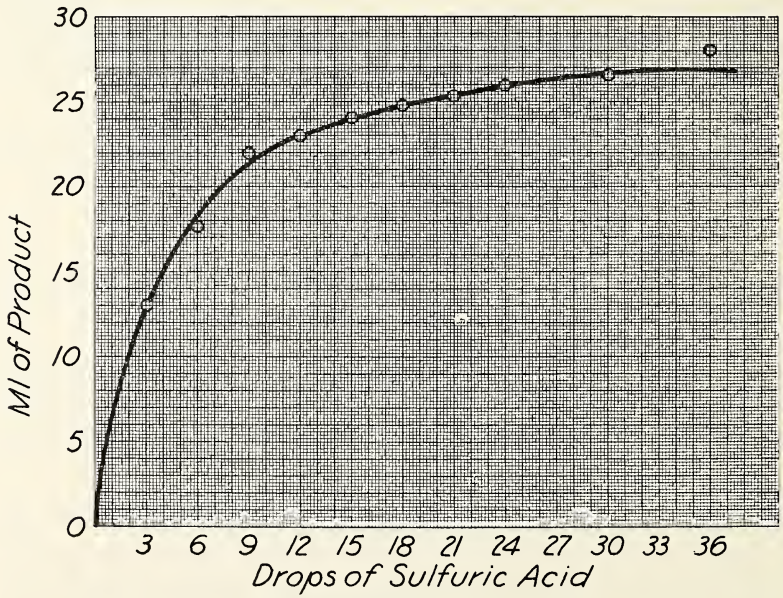

Figure 1

identified by several methods, including the determination of a saponification equivalent of the unsaturated ester and the formation of a 2,4-dinitrophenylhydrazone of the ketone obtained upon hydrolysis of the product. No attempt was made to determine the relative amounts of isomers obtained from this reaction.

According to expectation, a certain amount of ketene polymerization accompanies this reaction.

In determining the effect of catalyst concentration, the reaction time and reaction temperature were arbitrarily set at three hours and 75°C., respectively. The effect of varying the catalyst concentration is shown by Figure 1. Optimum results were obtained with a concentration of

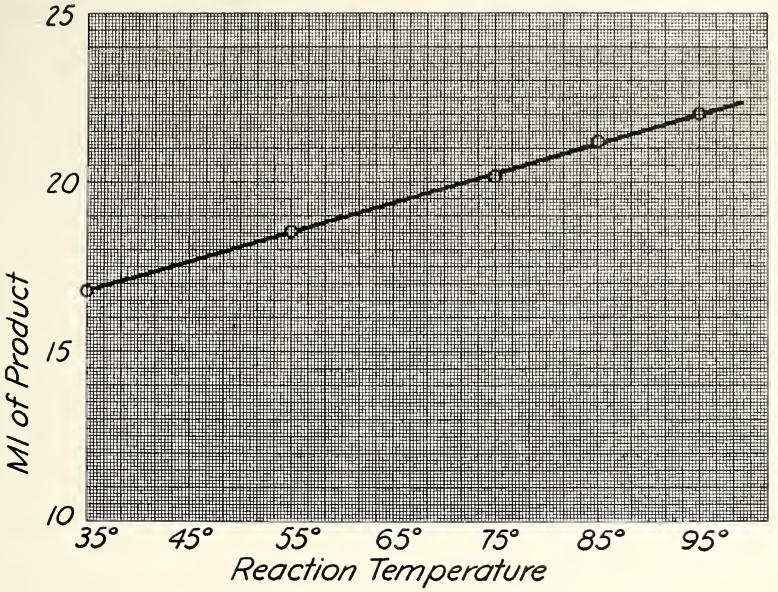

Figure 2

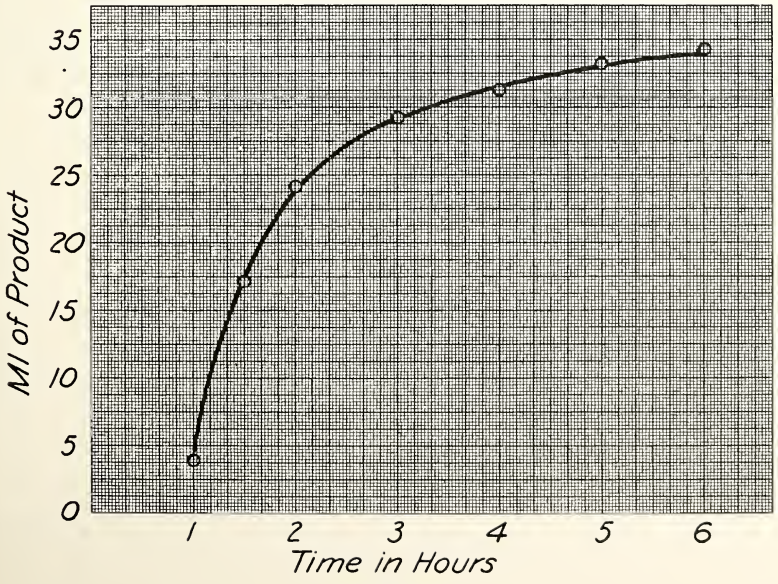

Figure 3

0.009 mole of sulfuric acid for each mole of 2-butanone. This optimum value may be calculated from Figure 1, which indicates that, under the experimental conditions, fifteen drops (0.5 milliliter) of sulfuric acid is the desired amount.

The effect of varying the bath temperature is shown by Figure 2. It will be seen that as the temperature is increased the yields of 2-buten-2-yl acetate are progressively increased, but due to operational difficulties which arise above 75°C., this temperature is taken to be optimum under the prevailing experimental conditions.

Figure 3 shows the effect of increasing the amount of ketene added to a given amount of methyl ethyl ketone. The amount of product increases quite rapidly for a time and then tends to approach a constant value. This fact may be brought about by a decrease in concentration of the methyl ethyl ketone which accompanies its utilization in the reaction. The optimum length of time for ketene passage was found to be approximately four hours, thus giving a value of one mole of ketene passed into the reaction mixture for 0.784 mole of methyl ethyl ketone employed.

Summary

A study has been made of the reaction between ketene and butanone to yield 2-buten-2-yl acetate. The optimum conditions determined for the reaction, as carried out on a batch scale, are with a rate of flow of 0.25 mole per hour of ketene through 0.784 mole of butanone in the presence of 0.007 mole of sulfuric acid at a temperature of 75°C. The conversion is about 39 per cent. No attempt was made to re-cycle the ketene and thus determine the overall yield. The polymerization of ketene is decreased by increasing the temperature of operation. Sulfuric acid was the most effective of the catalysts studied. The conversion of the butanone to 2-buten-2-yl acetate increases with the reaction time.

The Nitrogen Dioxide Oxidation of Starch*

J. W. Mench, with Ed F. Degering, Purdue University

Although the literature contains over two hundred references to the oxidation of starch, little is known concerning the structures of the products because various oxidants may simultaneously attack one or more of the hydroxl groups to produce a complicated structure containing carboxyl, aldehyde, and ketone groupings. An exception appears to result when periodic acid is used, since this oxidant seemingly exhibits a specificity towards parts of the carbohydrate molecule containing adjacent, secondary hydroxyl groupings.[1,2] The observations of Unruh, Yeckel, and Kenyon,[3,4] that cellulose can be oxidized with nitrogen dioxide to a polyanhydroglucuronic acid, indicate that this reagent preferentially attacks the primary hydroxyl groups in certain glycosides.

We have attempted to apply to starch both the static and cyclic method of oxidation reported by these men, in an effort to produce the *alpha*-linked polyanhydroglucuronic acids. However, the tendency of the powdered carbohydrate to pack made these procedures unsatisfactory, since the reactions were difficult to control and at least partial hydrolysis of the starch frequently occurred.

We have found, however, that under suitable conditions, starch may be oxidized by nitrogen dioxide to produce a new type of oxidized starch containing, predominately, uronic acid residues. This point was confirmed, qualitatively, by a positive *beta*-naphthol test,[5] which indicated the presence of glucuronic acid, although attempts to hydrolyze the products to glucuronic acid, and to prepare the cinchonine salt or oxime of this compound were without success.

The procedure and diluent utilized in this work was suggested by the work of Maurer and Drefahl,[6] who oxidized galactose, methyl glucoside, and methyl galactoside with nitrogen dioxide in carbon tetrachloride or chloroform—obtaining mucic acid and the corresponding substituted uronic acids, respectively. The method of oxidation is readily controlled so that oxidized starches of any desired carboxyl contents can be produced.

In marked contrast to the behavior of untreated starch, these products, even those with low carboxyl contents, do not dissolve in hot water. Since these products, presumably, exist as the free acids or as lactones, this would indicate that the carboxyl group is less water-solubilizing than is the primary hydroxyl grouping or considerable lactone formation has occurred, although nitrogen dioxide-oxidized celluloses show enhanced water-susceptibility with increasing carboxyl contents.[4] On the other hand, samples containing even small amounts of carboxyl groupings are

* This is an abstract of a portion of a thesis submitted by J. W. Mench to the Faculty of Purdue University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, June, 1944. American Maize-Products Co. fellow 1941-44. Present address, Eastman Kodak Company, Rochester, New York.

completely soluble in dilute, aqueous alkalies, and concentrated solutions of the alkali metal salts of these products do not retrograde upon cooling as do dispersions of untreated starch.

Premilinary work has indicated that some of the salts of these polyanhydroglucuronic acids might find application in the replacement of certain other modified starches and polyanhydrouronic acids as thickeners, gel-formers, dispersants, and stabilizers. The free acids have possible use as acidulants, dispersants, and disintegrates in certain food and medicinal products, and as a source of glucuronic acid.

Glucuronic acid, in turn, is a useful intermediate for the preparation of saccharic acid by the further oxidation with halides, electrolytically-generated halogens, or chlorous acids.[7] The production of *D-arabo*-trihydroxyglutaric acid from this intermediate is also feasible.[8] A further commercial application of glucuronic acid would be in the synthesis of ascorbic acid by methods analogous to those recently divulged by Regna and Caldwell[9] and Isbell.[10]

Experimental

All of the oxidations were conducted on a commercial grade of air-dried corn starch[11] which was given an additional 24 hour drying treatment in a vacuum oven at 55°C. and at a pressure of 10 mm. of Hg before use. The nitrogen dioxide employed was a commercial, Du Pont product, and the term refers to the equilibrium mixture of nitrogen dioxide and nitrogen tetroxide.

The apparatus consisted of a 250 ml. three-neck flask fitted with an efficient, rapid stirrer and a six-inch, spiral type reflux condenser. In all cases, 16.5 g. of starch was oxidized, which is equivalent to 0.1 mole when the residual moisture is taken into account. The diluent selected for the reaction was carbon tetrachloride, and it was usually used in the amount of 150 ml., although smaller amounts were also tested in order to determine the effect of higher initial concentrations of the oxidant. The nitrogen dioxide addition was facilitated by the use of a water-jacketed burette, the weight of the oxidant being calculated from density and temperature data.

All reactions were run at room temperature (25° to 29°C.), and after the desired time of oxidation, the products were filtered off on a Pyrex fritted-glass funnel, washed with carbon tetrachloride, and the excess solvent allowed to evaporate into the atmosphere. The oxidation products were then washed thoroughly with distilled water until the washings were free of acidity, followed by successive washings with acetone and ether. The latter solvent was allowed to evaporate, and the products were then given a more thorough drying over phosphorous pentoxide in a vacuum desiccator. The washing treatment just described completely removes all soluble materials such as excess oxidant or nitric acid, glucose, dextrins, or the organic acids which might be present because of partial hydrolysis and oxidation of the hydrolysis products of the starch.

The weight of oxidized starch obtained was always at least as great as the weight of starch used, and in the more highly oxidized samples, was usually somewhat greater.

Analysis of the Products:

The carboxyl contents of the products were determined by titration with standard alkali, as suggested by Unruh and Kenyon.[3] Although this is not as accurate as the method involving carbon dioxide evolution resulting from decarboxylation of the uronic acid residues, it was felt to be sufficiently accurate for comparison purposes. On oxidized celluloses, the method gives somewhat lower values than the carbon dioxide evolution method, especially at low carboxyl values, although it approaches the true value at the theoretical 25.5 per cent carboxyl content.

The method as used consisted in weighing 1 g. samples of the dried, oxidized starches into 250 ml. Erlenmeyer flasks, adding 30 ml. of 1 to 2 pyridine-water mixture, and heating on a steam bath until the samples were substantially in solution. The sides of the flasks were then washed down with 30 ml. of distilled water, and the contents titrated to a phenolphthalein end point with N/2 sodium hydroxide. The values obtained were corrected for by a blank titration on the solvent mixture.

Data:

Pertinent data and the results obtained are summarized in Table 1, and Figures 1, 2, 3, and 4 illustrate the relationships existing between

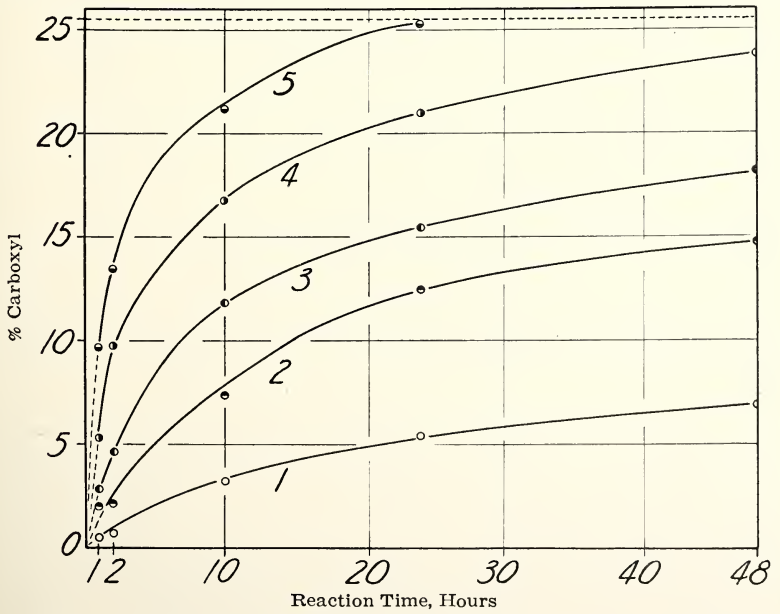

Fig. 1. The Relationship of Carboxyl Contents to the Time of Reaction at Various Ratios of Nitrogen Dioxide to Starch. Legend: Molar Ratio of Nitrogen Dioxide to Starch, 1. 1 to 1; 2. 2 to 1; 3. 3 to 1; 4. 5 to 1; and 6. 10 to 1.

the carboxyl contents of the products and some of the factors influencing the same.

Discussion:

A study of the data given in Table 1 and Figures 1 to 4 indicates that the reaction between nitrogen dioxide and starch is influenced by at least several factors:

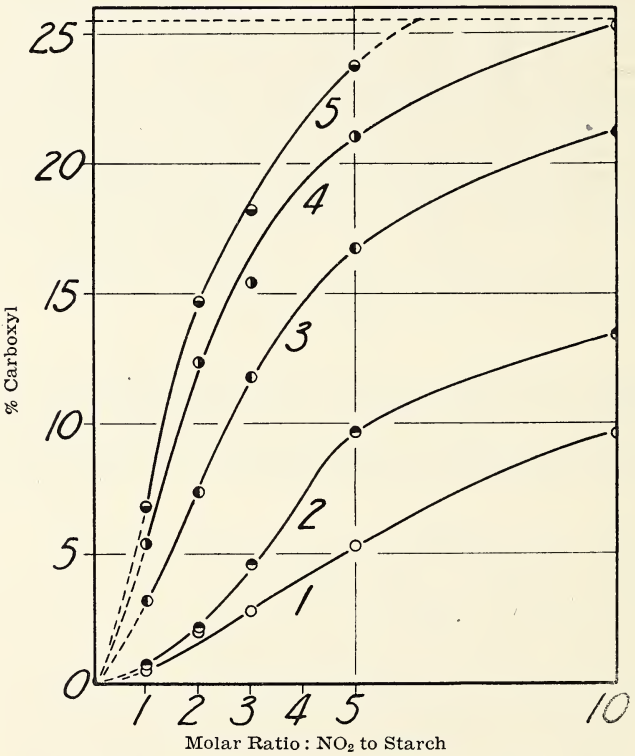

Fig. 2. The Relationship of Carboxyl Contents to the Ratio of Nitrogen Dioxide to Starch at Various Reaction Times. Legend: Reaction Time, 1. 1 hr.; 2. 2 hrs.; 3. 10 hrs.; 4. 24 hrs.; and 5. 48 hrs.

1. At a given molar ratio of oxidant to starch, the carboxyl content of the product is a function of the time of oxidation, increasing with the length of time of reaction. As shown in Fig. 1, the nitrogen dioxide rapidly oxidizes the starch in the early stages of the reaction, and then oxidation slows considerably. This may be due to loss of a portion of the oxidant through the reflux condenser and stirrer bearings over a long period of time, although the same effect was observed by Yackel and Kenyon[4] in their static cellulose oxidations, which were conducted in sealed containers.

2. At a given time of oxidation, the carboxyl content of the product is a function of the molar ratio of oxidant to starch, increasing as the

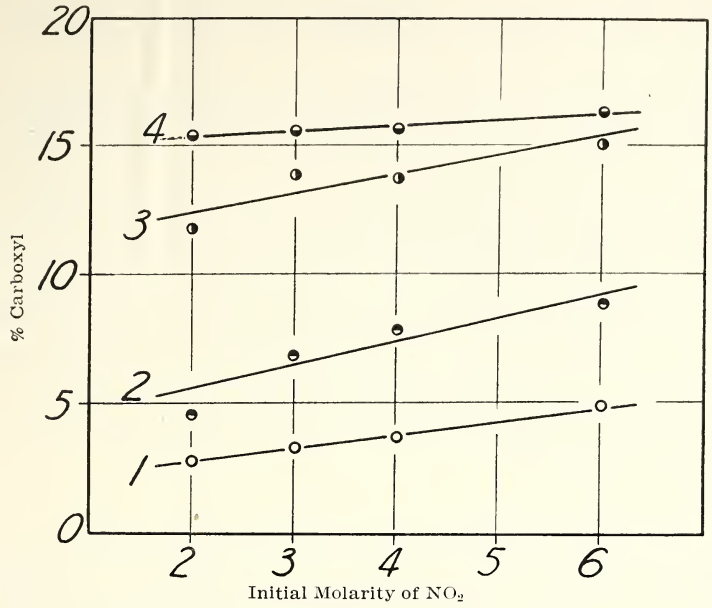

Fig.3. The Relationship of Carboxyl Content to the Initial Molarity of Nitrogen Dioxide at Various Reaction Times. Legend: Reaction Time, 1. 1 hr.; 2. 2 hrs.; 3. 10 hrs.; and 4. 24 hrs.

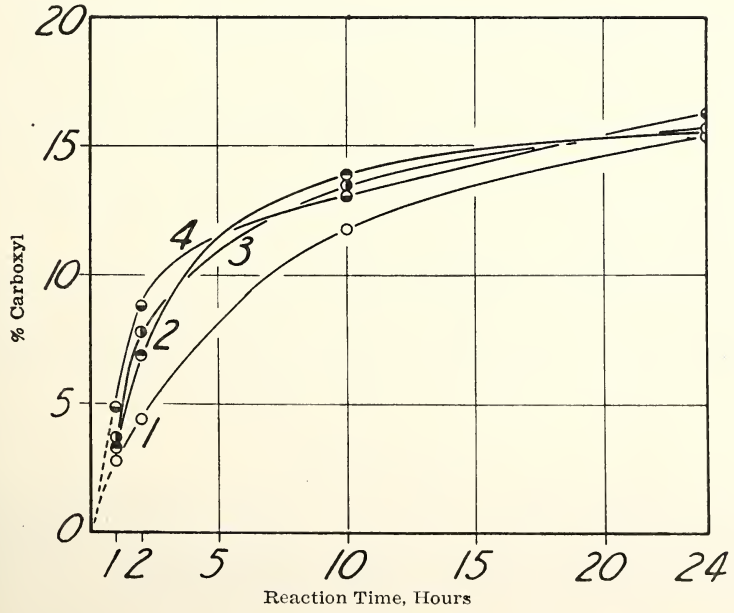

Fig. 4. The Relationship of Carboxyl Contents to the Time of Reaction at Various Initial Molarities of Nitrogen Dioxide. Legend: Initial Molarity of NO_2, 1. 2 *M*; 2. 3 *M*; 3. 4 *M*, and 4. 6 *M*.

molar ratio of the oxidant is increased. This effect is illustrated in Fig. 2.

It was thought that an increase in the initial concentration, or molarity, of the nitrogen dioxide might have the effect of increasing the carboxyl content without the use of large excesses of oxidant. This was tested by arbitrarily choosing an oxidant to starch ratio of 3 to 1, which is somewhat over the theoretical ratio of 2 to 1 required for the conversion of a primary hydroxyl group to carboxyl, and decreasing the amounts of carbon tetrachloride used as diluent. The results of these experiments, however, (cf. Fig. 3) indicate that at a given molar ratio (3 to 1) of oxidant to starch, and at a given time of oxidation, the carboxyl content of the product increases only slightly with an increase in the initial concentration of the oxidant. This effect is further illustrated in Fig. 4, in which carboxyl content has been plotted against the time of reaction at constant values of initial oxidant molarity. These curves almost coincide, with the exception of the one run at the lowest concentration (2.0 molar).

Properties of the Products:

One of the most surprising properties of these oxidized starches, even those with comparatively low carboxyl contents, is their insolubility in hot water. This is in marked contrast to the behavior of untreated starch, which is easily dispersed at elevated temperatures. All of the products, however, dissolve readily, when warmed, in dilute bases such as 2 per cent sodium hydroxide, 2 per cent sodium carbonate, dilute ammonium hydroxide, aqueous solutions of quaternary ammonium hydroxides such as Triton B, and aqueous pyridine. They are also soluble in 5 per cent sodium bicarbonate, liberating carbon dioxide from the solution. Unlike untreated starch, these products do not retrograde when fairly concentrated solutions containing their salts are cooled. The free salts may be obtained by precipitation of their aqueous solutions with ethanol or other water-miscible solvents, but the free acids are not easily regenerated by rendering the solutions acidic. This suggests that the uronic acid residues are hydrolyzed with ease.

As is the case with oxidized celluloses,[4] salts of other metals may be readily prepared by treatment of the oxidized starches with aqueous solutions of the metal acetates, since the polyanhydroglucuronic acid is strong enough to displace acetic acid from its salts. Polyvalent cations, as in the case of oxidized celluloses, yield water-insoluble salts.

Acknowledgment

The authors wish to express their sincere appreciation to the American Maize-Products Company and to its Director of Research, Dr. H. H. Schopmeyer, for the generous provision of funds, in the form of a fellowship, which made this and other research possible.

Summary

1. A method for the oxidation of starch with nitrogen dioxide is described, which results in the production of *alpha*-linked polyanhydroglucuronic acids. The oxidation is readily controlled to yield products of any desired carboxyl content.
2. The carboxyl content of the product is dependent, mainly, on the time of oxidation and the molar ratio of oxidant to starch, whereas the initial concentration of the nitrogen dioxide seems of less importance.
3. Methods of preparation of various salts of the oxidized starches are described.
4. The properties of the oxidized starches, and of their salts, have been described, and uses based on these are suggested.

Table 1. The Oxidation of Starch with Nitrogen Dioxide

Run	Molar ratio: NO_2/starch	Ml of CCl_4	Initial Molarity of NO_2	Time of Oxidation (hours)	Yield of washed product (grams)	% COOH
1	1	150	0.67	1	16.20	0.5
2	1	150	0.67	2	16.60	0.7
3	1	150	0.67	10	16.90	3.2
4	1	150	0.67	24	17.40	5.4
5	1	150	0.67	48	17.72	6.9
6	2	150	1.33	1	16.50	2.0
7	2	150	1.33	2	16.92	2.1
8	2	150	1.33	10	17.36	7.4
9	2	150	1.33	24	17.12	12.4
10	2	150	1.33	48	16.70	14.7
11	3	150	2.00	1	16.30	2.8
12	3	150	2.00	2	16.80	4.6
13	3	150	2.00	10	18.46	11.8
14	3	150	2.00	24	17.28	15.4
15	3	150	2.00	48	16.68	18.2
16	3	100	3.00	1	17.43	3.3
17	3	100	3.00	2	17.79	6.9
18	3	100	3.00	10	18.25	13.9
19	3	100	3.00	24	18.34	15.6

Run	Molar ratio: NO_2/starch	Ml of CCl_4	Initial Molarity of NO_2	Time of Oxidation (hours)	Yield of washed product (grams)	% COOH
20	3	75	4.00	1	17.90	3.7
21	3	75	4.00	2	17.68	7.8
22	3	75	4.00	10	19.56	13.7
23	3	75	4.00	24	18.34	15.7
24	3	50	6.00	1	18.40	4.9
25	3	50	6.00	2	18.23	8.8
26	3	50	6.00	10	18.38	15.1
27	3	50	6.00	24	18.45	16.3
28	5	150	3.33	1	17.36	5.3
29	5	150	3.33	2	17.87	9.7
30	5	150	3.33	10	19.12	16.7
31	5	150	3.33	24	18.59	21.0
32	5	150	3.33	48	17.72	23.8
33	10	150	6.67	1	18.15	9.6
34	10	150	6.67	2	18.60	13.4
35	10	150	6.67	10	19.13	21.2
36	10	150	6.67	24	18.85	25.3

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GEOLOGY and GEOGRAPHY

Chairman: E. R. SMITH, DePauw University

Professor G. D. Koch, Indiana State Teachers College, Terre Haute, was elected chairman of the section for 1946.

The Cataract Falls sandstone of the Ste. Genevieve formation in Southwestern Indiana. CLYDE A. MALOTT, Indiana University.—In and about the double falls of Mill Creek near Cataract, Owen County, Indiana, more than 100 feet of Mississippian strata are well exposed, revealing all of the Ste. Genevieve formation, on top of the St. Louis limestone below, and two or more Chester formations at the top. The upper Cataract falls is over a massive, fine-grained, calcareous sandstone at least 23 feet thick which occupies nearly the middle one-third of the Ste. Genevieve formation of 76 feet in thickness as exhibited in and near the two falls. Above the sandstone are 22 feet of Ste. Genevieve limestone up to the thin Aux Vases sandstone exposed a few feet above the dam near the upper falls. The lower Ste. Genevieve limestone at the lower falls is 30½ feet in thickness and rests unevenly on the St. Louis limestone about 10 feet above the plunge pool of the falls. Examination of the Ste. Genevieve at other localities both north and south of the Cataract falls reveals that the same sandstone is quite persistent, varying from one foot in thickness to more than 30 feet. This sandstone is probably the stratigraphic equivalent of the Rosiclare sandstone of southern Illinois, but its remoteness makes the correlation somewhat uncertain. The name *Cataract Falls sandstone*, here proposed, is quite appropriate for it in southwestern Indiana.

Iron and Steel Industries of Manchuria

Muzaffer Erselcük, Purdue University

Although it would seem to the causal observer that little or no connection exists between Manchurian iron and steel and the state of Indiana, still there is a very definite link, the result of the perpetual motion of international trade. It will be remembered that Indiana is one of the larger producers of iron and steel. Naturally any developments in the iron and steel industry even in Manchuria, halfway around the world, will cause unmistakeable repercussions even in Indiana.

Since the Japanese occupation of Manchuria in 1931 striking developments have occurred in the expansion of Manchuria's iron and steel industry in the following phases:

1. Discovery of new deposits of raw materials for the production of iron and steel, especially of coal and iron ore.
2. Development of technology for utilizing low-grade iron deposits.
3. Modernization of the existing equipment and the building of new production facilities.

These were not the result of haphazard developments by private enterprise, but of methodical planning by the Japanese government, which wanted to insure a large supply of iron and steel for the constantly growing needs of industries in Japan proper. Naturally the important role of iron and steel in waging war was also kept well in mind. Japan was not alone in such activity, however; the development of iron ore and coal resources as well as the construction of blast furnaces and steel mills was being pushed at government expense during the decade preceding the Second World War in Russia, Germany, Italy, Poland, Rumania, Turkey, and Yugoslavia.

In 1929 the Manchurian production of iron ore and coal as well as of pig iron was exceedingly small, and no steel ingots or rolled steel were produced. During the first years of the Japanese occupation, there was a considerable increase in production of pig iron and its raw materials, but the large-scale expansion program did not start until 1937, as will be seen from the following figures:[1]

	In metric tons		
	1929	*1937*	*Goal for 1942*
Iron ore	986,000	2,257,000	12,000,000
Pig iron	294,000	739,000	4,860,000
Steel ingots	.....	427,000	3,500,000
Rolled steel	.....	370,000	2,000,000
Coal	10,024,000	12,540,000	38,000,000

[1] Schumpeter, E. B., et al., 1940. *The Industrialization of Japan and Manchukuo*, p. 388.

Raw Materials

Iron. Most of the known iron deposits in Manchuria are found in the southern and central regions of the country. In the north only small deposits have been discovered to date. The largest part of the Manchurian ores belong to the "Archean" type, which is credited with a possible two billion tons containing just under 35 per cent metallic iron. The ore body is found in an irregular linear zone stretching from the Sea of Japan coast of Northeastern Korea to Lunghsien in Hopeh, passing across Southern Manchuria and going under Liaotung Bay. Although the length of the ore zone is about 400 miles, the mineralized area is narrow.

In addition to the lean ores, in a few places localized pockets of rich ore containing 60 per cent or more metallic iron appear. At least 95 per cent of the ores, however, may be classified as poor, containing only 30-35 per cent metallic iron. On the basis of the most recent available data, the iron reserves of Manchuria may be estimated at over three billion tons, with a metallic content of 1.3 billion tons.

The important reserves are located in two areas, the Anshan-Waitoushan-Miaoerhkou triangle in Fengtien and the Tungpientao zone in Tunghua province. The former has a proved iron reserve of 1,168 million tons of lean ores and ten million tons of rich ores, or about 393 million tons of pure iron. The latter, not yet fully studied, is estimated to have reserves of about 1,500 million tons, with a fair proportion of high-grade ores. Besides these two areas, some iron is found in Central Manchuria, southeast of Hsinking.

On the basis of proved deposits, the production of pig iron at the rate of 5,000,000 tons annually can continue at least for another 200 years.

Coal. Geological investigations since 1932 have pushed estimates of coal reserves in Manchuria from 4,800 million to about 20,000 million tons.[2] Many other rich coal fields are anticipated as results of further surveys, raising the aggregate deposit figure still higher. In regard to thermal power and heat for steel furnaces and rolling mills, the coal supply is more than sufficient; however, only three groups of mines with aggregate known reserves of not more than 500 million tons of coal produce a high-grade metallurgical coking coal—that of Penhsihu in Fengtien, those of Tungpientao in Tunghua, and those of Mishan in Northeastern Manchuria. The total production capacity of these mines is about 2.5 million tons, much less than the requirements of the existing blast furnaces. To make conditions even worse, the Mishan mines, with a production capacity of about a million tons, are 650 miles away from the main blast furnace center of Anshan, and it is more advantageous from the point of transportation economy for the Mishan mines to ship coal to the Seishin blast furnaces in Korea rather than to Anshan. This leaves only about 1.5 million tons of coking coal for Manchurian blast furnaces, which therefore must import coking coal from North China.

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[2] Cressy, G. B., 1944. *Asia's Lands and Peoples*, p. 114.

Technology

Since most of the iron deposits in Manchuria are low-grade in nature, the Japanese scientists paid much attention to the beneficiation of iron ores. Since smelting costs rise rapidly with the higher amount of slag-forming constituents in the ore, and since Manchuria is already short in suitable smelting fuels, the beneficiation of iron ore was absolutely necessary, and it was inevitable that it should become an important part of the iron and steel industry.

Some of the beneficiation processes used in Manchuria were:

1. Anshan-type lean-ore-disposition process
2. Krupp-Renn process
3. Magnetic concentration
4. Flotation
5. High-frequency process.

Manufacturing facilities

Manchuria has four blast furnace centers: Anshan, Penhsihu, Mianohara, and Tungpientao.

Anshan. Plans were made in 1917 to construct a plant comprising eight blast furnaces, with a production capacity of one million tons. In 1919 the first blast furnace was completed and the second began operations a year later. It was soon discovered that the plant had been constructed without a careful examination of available raw materials. Attempts to use the low-grade ores in the vicinity of Anshan was unsuccessful because these ores are high in silicon content. Limestone had to be carried to the furnaces from a distance of 50 miles.

Continuous research solved the problems created by low-grade ores and the Anshan-type lean-ore-disposition method was patented. The concentration factory was completed in 1926.

After the conquest of Manchuria by the Japanese, the capacity of the existing furnaces was increased from 250 tons to 350 and a number of new furnaces were built. As a result, at the time of the Japanese surrender in August, 1945, the total capacity of the Anshan works was 2,781,000 tons of pig iron.

It was originally expected that coal from the huge, world-famous open pit mine at Fushun would be used as fuel, but it was later discovered that coal from Fushun does not produce a satisfactory metallurgical coke, and thus it was necessary to obtain coal from other collieries. Until 1942, Kaiping coals from Hopei were imported and mixed with Fushun coal in order to obtain a suitable coke. To augment the supply of coking coal the Japanese in 1943 completed a railroad across the Mongolian steppes and connected the Tatung coal mines in Suiyuan with Anshan. Incidentally, the same road carries high grade iron from the Lungyen mines in Chahar, which is mixed with enriched and lean ores from Anshan, Kyuchorei, and Waitoushan mines near Anshan and from the mines of the Kyowa Company in Central Manchuria.

The Anshan plants get their limestone from deposits at Kanchingtzu and Huolienchai, and magnesite and dolomite from Niuhsinshan. Fireclay is purchased from the Yentai coal mines.

The pig iron was for the most part converted into steel at Anshan. Some pig iron, as well as a large amount of steel ingots, were exported to Japan for further processing.

Penhsihu. This plant with two 250-ton furnaces was completed during the First World War. In 1939 it was decided to enlarge its capacity. The first new blast furnace was put into operation in December, 1940, and the other was completed in March, 1941, bringing the total capacity to 500,00 tons of pig iron a year.

Penhsihu occupies the most convenient position for the gathering of materials needed in the manufacture of pig iron. Large limestone deposits exist near Penhsihu, the product of which is transported directly to the limestone yard of the plant from the quarry by means of a mile-long aerial cable. The iron ore is shipped from the Miaoerhkow mine about 25 miles to the southwest. The main factor in locating the plants at Penhsihu, however, was the abundance of coking coal reserves, estimated at 190 million tons, which are found in the vicinity of the plants.

Mianohara. In order to utilize the cargo space of the empty railroad cars returning from Penhsihu after delivering their load of iron ore from the Miaoerhkow mines, it was decided to build a smelting plant at Mianohara, near the mines. The coking coal for this plant was to be shipped in from Penhsihu. The first blast furnace was put into operation in October, 1941, and another by the end of 1942. The new plant, which contains steel-making facilities, was to be in full operation by 1943.

The low-phosphorus pig iron produced at Mianohara and Penhsihu constitutes an essential raw material for manufacturing high-grade steel.

Tungpientao. The Tungpientao region has large deposits of coking coal and high-grade ore. The Tungpientao Company, which operates both the coal and iron mines, has two blast furnaces completed during 1942-43. The pig iron produced was exported to Japan.

Other plants. Besides the above-mentioned large units, there are three small plants engaged in the production of pig iron and sponge iron.

Conclusion

Political and military, rather than economic, considerations were responsible for the rapid growth of the iron and steel industry in Manchuria. As long as strategic factors determined the existence of such industries, large subsidies were available to maintain and operate them.

With the collapse of Japan, non-economic considerations have undergone a drastic change and the iron and steel industries of Manchuria as a whole do not have an economic foundation to stand upon. Therefore the question arises of their future.

Assuming that the Russians will not remove the installations and will maintain them in good condition, the new owners of these industries, the Chinese, will face two alternatives.

1. To let the unneeded capacity of the plants lie idle until the day Chinese industrialization will warrant their use.

2. To operate the plants and export the unneeded part of the production until the total production could be utilized in China. It is probable that the Chinese leaders would prefer this alternative. However, this means not only employing foreign technical help in order to manage the plants, but also paying large subsidies, a doubtful condition for the poor Chinese finances.

In conclusion, therefore, one may say that the Manchurian iron and steel industry probably will not furnish any serious competition to that of America in the international markets for some time to come.

Geologic Contrasts in Indiana State Parks

Otis W. Freeman, Indiana University

The state parks of Indiana, with sites selected largely for scenic and historic reasons but partly with the intent to secure wide geographical distribution for recreational purposes, contain a fairly complete sequence of the geological formations outcropping in the state, besides providing examples for a large majority of the physiographic principles. Evidence of vulcanism is one of the chief things missing, since all of the exposed bedrock in Indiana is of sedimentary origin. Even so, many types of igneous and metamorphic rocks can be picked up among the glacial boulders in the northern part of the state.

The oldest exposed rocks are those of the Ordovician period. Excellent outcrops for the study of the Ordovician strata occur in southeastern Indiana on the west flank of the Cincinnati Arch. The beds are highly fossiliferous and one of the famous collecting grounds for the life forms of this period is near Madison.

Clifty Falls State Park includes strata classified in the upper Ordovician, the Silurian and base of the Devonian periods. The Silurian rocks occupy the hill slopes above the falls and inner gorges in the park with the Devonian capping the higher hills.

The Ordovician formations in the park area from the base upward, begin with 25 feet of the Bellevue, followed by 115 feet of the Arnheim, 55 feet of the Waynesville, 50 feet of the Liberty, about 32 feet of the Saluda and possibly 6 feet of Whitewater. Shale predominates from the Bellevue through the Liberty and is interbedded with thin layers and lenses of limestone, and in contrast the Saluda is a thick bedded limestone with reef corals occuring near its base. The Saluda resists erosion so that being underlain by the crumbly Liberty beds, the limestone forms a waterfall ledge in the streams that flow across it. Clifty, Little Clifty, Hoffman, Tunnel and other falls all have developed at the outcrop of the Saluda in the streambeds. Hanging Rock on Highway No. 7 near Madison is another good example of the ledge forming qualities of the Saluda limestone.

Clifty Falls has a vertical drop of about 50 feet in a total descent of 70 feet. It is easy to walk back of the falls and observe how the splashing and spray from the falling water along with other factors cause the weak Liberty formation to weather and erode thus creating a considerable niche. This process undermines the Saluda limestone and at intervals, perhaps of many years, a block breaks off. Since the first plunge developed from the cliffs at the edge of the Ohio Valley, the falls have retreated upstream leaving a steep, narrow gorge downstream. In all Clifty Falls has retreated about 11,000 feet and, separating from Clifty Creek, the various tributaries each have worn a gorge that ends in a waterfall. In addition to the work by running water and weather-

ing that largely account for the talus accumulations at the base of the cliffs, the work of ground water is shown through the presence of seeps, springs and small landslides.[1]

In 1897 Professor Glenn Culbertson of Hanover College described[2] preliminary work that he hoped would permit the approximate determination of the time required for the erosion of Clifty Falls. In 1911[3] he noted that in 14 years between 1897 and 1911 the undermining at Clifty Falls amounted to four and one-fourth inches. His son, J. A. Culbertson, found in 1927,[4] 30 years after the spike used for measurement was driven into the rocks behind the falls, that the mists had caused a total sapping equal to seven and one-eighth inches. This is about one-fourth of an inch per year for the 30 years. Assuming that the volume of water and rate of recession has been continuously at this rate, about half a million years would have elapsed since the falls began early in the Glacial epoch. Further studies here will be of interest.

The newly established state park near Versailles and the projected Whitewater Park southwest of Liberty in Union county are underlain by the shales of the Richmond (Upper Ordovician) group. However, the strata are not so well exposed or so extensive as in Clifty Falls State Park although including much the same beds. In part the rock outcrops are masked by superficial glacial deposits.

The next park in stratigraphical sequence is Muscatatuck State Park near Vernon. Here the surface formation is the New Albany shale of Devonian age. Below these beds, near the ruins of the Vinegar mill are around 60 feet of Devonian limestones (Beechwood, Jeffersonville, and Geneva), with the Louisville and shows of Waldron shale of Silurian age appearing near the banks of the river. Thus the base of the strata at Muscatatuck State Park coincides with the top beds at Clifty Falls State Park.

Tippecanoe State Park is primarily of historical interest, but, for the record, it may be mentioned that beneath a cover of glacial drift the bedrock of the area is the New Albany shale of Devonian age.

The older school of Indiana geologists called the sandstones and shales of lower Mississippian age, the Knobstone, naming the formation from the rounded hills that are developed from it by erosion. This formation extends from opposite Louisville northward through Lloyd, Washington, Jackson, Brown and eastern Monroe counties. The name Knobstone has been superseded by the name Borden, but anyone who has seen the peculiar looking conical knobs that erosion has developed from this formation will recognize how good a descriptive term Knobstone was. Stockdale[5] estimated that the Borden in southern Indiana has an areal extent of 1,880 square miles, and to vary in thickness from 400

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[1] More about the geology of Clifty Falls State Park is given by the author in Outdoor Indiana, **12**, July, 1945, 10-11.

[2] Proc. Ind. Acad. Sci. 1897, 242-243.

[3] Proc. Ind. Acad. Sci. 1911, 169-170.

[4] Proc. Ind. Acad. Sci. 1927, **37**:118.

[5] Stockdale, Paris B., *The Borden Rocks of Southern Indiana*, Pub. No. 98, Dep't of Conservation, Indianapolis, 1931, p. 5.

feet at the Ohio River to double that in Brown County.[6] In central Indiana the Borden consists of sandstone and shale with occasional lenticular limestone beds. The famous Brown County scenery is all developed upon the Borden.

The Brown County State Park contains rocks of the Borden formation only. Erosion has not been deep enough to expose the underlying New Albany shale, and the overlying Harrodsburg limestone does not occur anywhere in Brown County. Stockdale reports 760 feet of Borden,[7] including subsurface, at Nashville close to the park. Sandstone members of the Borden are fairly resistant and account for the flatish summits of some of the ridges. Narrow ravines are common, and slumping by weak shales that lie under the sandstones help to maintain steep slopes to the hills. Numerous quartz geodes occur in certain horizons of the Borden strata. Some of the beds are quite fossiliferous. Bioherms, composed largely of crinoid stems, occur in the upper Borden. All of these features, along with examples of weathering and the work of water erosion can be seen in Brown County State Park. Although the State Park area was not invaded by glaciers, melt water from the ice sheet crossed Brown County and deposited gravel and silt. From the fire tower there is a superior view of the pre-Pleistocene dissected peneplain, correlated with the Highland Rim Peneplain of Kentucky and Tennessee, preserved in southern Indiana chiefly on the harder rock formations. The base of the fire tower is 1,060 feet in elevation above sea level and Salt Creek is 600 feet, giving a maximum difference in relief of 460 feet. The north lookout is 290 feet above the creek and Abe Martin Lodge is 160 feet.

Four Mississippian limestone formations lie above the Borden and have been named the Harrodsburg, Salem, St. Louis and St. Genevieve. Throughout south-central Indiana these limestones have been affected by solution from ground water that has resulted in numerous caves, sinkholes, lost rivers and other features of karst topography.[8] Among the caverns, Wyandotte and Marengo are best known, being famous for their curious stalactites and other deposits. Although privately owned, these caves are seen by thousands of visitors each year. Water-coursed caverns of considerable size are found in Spring Mill State Park, and the work of underground water is also important at McCormick's Creek State Park. The strata in both these parks that are especially subject to the formation of caves are the St. Louis and St. Genevieve limestones. The Salem limestone occurs below the St. Genevieve in both parks but is nearly devoid of bedding planes, is fairly soft and quite porous. These characteristics permit ground water to percolate through it easily so that the Salem is less readily dissolved to form caves. The Salem is the source of the Indiana limestone for building purposes, and in McCormick's Creek State Park near the White River is an old quarry which provided some of the stone used in constructing the state

[6] Stockdale, op. cit., pp. 56-62.

[7] Stockdale, op. cit., p. 62.

[8] Malott, C. A., Significant Features of the Indiana Karst, Proc. Ind. Acad. Sci., vol. 54:8-24, 1945.

capitol. In contrast, the Harrodsburg, St. Louis and St. Genevieve are rather dense and have many fractures, joints and bedding planes along which the water dissolves the limestone. Hence caves are scarce in the Salem and common in the other limestones mentioned.

An underground river flows through the caves in Spring Mill State Park, and the presence of blind fish in the cave water and the chance of a boat ride underground always interest visitors. The Spring Mill caves appear rather youthful as they are still in process of formation by solution and erosion. The deposition of calcite by dripping ground water, apt to occur in a mature stage in the life history of caves, has not yet been attained.

At McCormick's Creek State Park numerous sinkholes and springs, with some of the springs carrying the outflow from cavernous drainage, provide evidence of the work of ground water. As mentioned previously, the underground drainage is characteristic of the St. Louis and St. Genevieve limestones only. The maximum difference in relief in the park is 220 feet between White River and near Camp Friendly. The most spectacular feature of the park is the narrow gorge of McCormick's Creek that terminates with a drop of 65 feet between just above and just below the falls. The total drop of McCormick's Creek in its lower course is 160 feet in about two miles. Most of the gorge is believed to have been worn in post-glacial time. While the limestone bedrock has been an important factor in the development of the park scenery, the surface features of the area that includes the park, called the Flatwoods, have been modified by the continental glacier.

Siebenthal[9] and Malott[10] agree that the continental glacier crossed the White River and invaded the Mitchel Plain about two miles east of Spencer. The ice dammed the drainage into White River and formed a temporary lake in the Flatwoods area. A similar ponding occured in the valley of Bean Blossom Creek, and the water from these combined glacial marginal lakes overflowed southward to the west of Ellettsville and into Raccoon Creek according to Malott. With the disappearance of the ice the considerable descent of McCormick's Creek permitted that stream to secure most of the surplus water from the Flatwoods. This was favored by the underground drainage channels in the St. Louis limestone that helped to feed McCormick's Creek. In a way this capture of drainage is an example of underground piracy. The two mile long gorge in the State Park is considered by Malott to be largely post-glacial although he thinks the canyon may have been begun by underground drainage. The deep gorge seemingly was the result of the combined action of solution and possible collapse of the cave roof and of stream erosion, the latter being probably the more important factor.

The Chester formations, of upper Mississippian age, are composed of interbedded layers of sandstone, limestone and shale. Areally the Chester lies just west of the exposures of the cavernous Mississippian limestones just discussed. Erosion of the Chester has resulted in in-

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[9] Siebenthal, C. E., 21st Ann. Rept., Ind. Geol. Surv., 1896, p. 302.
[10] Malott, C. A., 39th Ann. Rept., Ind. Geol. Surv., 1914, pp. 217-222.

teresting gorges, picturesque cliffs, wooded hills and sparkling waterfalls, fully as great in scenic interest as in some of the established state parks, but no park area includes any of the Chester formations. Perhaps in the future this will be changed, since the Chester possesses a zone of mineral springs, such as French Lick and West Baden in western Orange County, and Trinity and Indian springs in Martin County.

Two popular state parks are located where the surface bedrock belongs to the Pennsylvanian system, which contains the coal deposits of Indiana. Turkey Run State Park and the nearby Shades, a private recreational area, contain gorges carved from the Mansfield formation at the base of the Pennsylvanian. Shakamak State Park is located on strata belonging to the Petersburg formation, about 300 feet above the Mansfield stratigraphically.

The Mansfield consists mostly of a coarse and often cross-bedded sandstone but includes some beds of shale and generally a thin seam of coal toward its base. Cross-bedding is considered proof of the deposition of the Mansfield near or above sea level where shifting current's operated. The Mansfield is massive and resistant. Wherever the streams have cut valleys into bedrock, cliffs of sandstone rise almost vertically for 50 feet or more. In places Turkey Run gorge is not half as wide as it is deep. Numerous potholes, waterfalls, eratic boulders and fallen rocks are features of interest in addition to the wooded, overhanging cliffs. A fine virgin forest delights the nature lover. Springs at the base of the sandstone above a layer of impervious shale illustrate a common cause for this phenomena.[11]

Shakamak State Park is situated in a rather flat area with a difference of elevation within its boundaries of 85 feet, perhaps more than might appear to the visitor. Two artificial lakes occupy much of the principal valleys and cover some of the outcrops so that exposures of bedrock are uncommon. However, in one place a coal bed is exposed as an exhibit. In the vicinity of the park are some of the largest coal mines in the state. Some of the mines are operated through shafts, others are strip mines.

Northern Indiana is deeply covered by glacial drift and the surface features of the state parks there are of Pleistocene or Recent age. The kind and age of the bedrock under the glacial debris has no significance. Pokagon and Indiana Dunes are the most popular parks in this part of the state, but Tippecanoe, Mounds and Bass Lake Beach are also attractive.

Pokagon State Park on Lake James is a good example of a region deeply covered by drift, in places 500 feet thick, where lakes of glacial origin are abundant. Moraines, kames, kettleholes, outwash deposits, erratic boulders and other evidences of glaciation are everywhere. Both Lake James and Bass Lake are examples of glacial lakes.

In northern Indiana are three abandoned beaches and associated deposits formed by prehistoric, glacial Lake Chicago when it stood at

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[11] Freeman, O. W., *Geology and Turkey Run State Park,* Outdoor Indiana, 12, 12-13, August, 1945.

55, 35 and 20 feet above the present level of Lake Michigan. Sand dunes often are associated with the old beaches. The dunes of Indiana Dunes State Park are being formed at the present time, the needed sand being derived from glacial deposits eroded by the waves from the shores of Illinois and southern Wisconsin and Michigan. Currents carry the sand to the south end of Lake Michigan where it is washed on to the beach. After drying, the prevailing winds blow the sand inland and the process of dune formation begins. The dunes are of two principal types: fore dunes and blowout dunes. The fore dunes form at the edge of broad beaches on which sand is accumulating and are usually 20-50 feet high, but occasionally attain a height of 100 feet. Blowout dunes result when, after vegetation has stabilized the fore dunes, the cover is destroyed in some way and the wind blows the sand away to cut trenches through the older dunes and dump the sand to leeward. The resulting big active tongues of sand are the most spectacular feature of the park. Blowout dunes are the highest hills in the park, Mount Tom reaching 193 feet above the lake with Mount Holden and Mount Jackson rising nearly as high. In their advance the blowout dunes invade the forest and kill the tress, cross marshes and may bury buildings or cover highways.[12]

The mounds in Mounds State Park near Anderson were built by Indians many centuries ago. Beneath a cover of glacial debris in a stream valley are exposures of the Niagara formation of Silurian age, but the outcrops of bedrock are of less interest than the constructions by prehistoric man.

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[12] For further information about the Indiana dunes consult: Cressey, George B., *The Indiana Sand Dunes and Shore Lines of the Lake Michigan Basin*, Geog. Soc. of Chicago, Bull. 8, 1928. Freeman, O. W. *Outdoor Indiana*, **12**, Sept. 1945, 12-13 and 16.

Needed, More Secondary School Geography

G. David Koch, Indiana State Teachers College

On December 7, 1941, America discovered geography. Since that catastrophic day, nearly four years ago, a renewed interest has developed in geography. During the war which ended recently our newspapers and magazines offered daily spectacular lessons of a geographic nature. Almost every home in the United States has a special interest in a place or places heretofore wholly unknown. With the war ended and peace conferences common happenings, we are beginning to realize that a "just peace" and a stable "world order" are securely bound up with a thorough knowledge of geography. Unless the geographic aspect of all problems that face the framers of peace are weighed carefully, any formal peace agreements will be fruitless.

Together with a renewed interest in geography as a nation, there is now underway a widespread movement for the reintroduction of geography into the secondary schools of the country. Courses of study and work programs are being arranged to meet the special demands and capacities of teachers and prospective teachers in the field of geography.

The inclusion of geography in the secondary school curriculum, and taught by teachers specially trained in that area, are timely and of paramount importance. Our young men and women are leaving high school with little or no training in geography. Their knowledge of the world, not to mention their own country, is unpardonable. Data compiled from over five hundred students enrolled in the introductory geography course at Indiana State Teachers College during the past five years indicates that slightly over one-fourth, or twenty-seven per cent, of these young people had received any instruction in geography during their secondary school training. Informal questioning of those students who had taken geography in high school further revealed that the courses were largely limited to physical or economic-commercial geography. In most cases the teachers of these courses were wholly untrained in geography, and quite likely, professed little or no knowledge nor any interest in the subject. Filling out exercises in a workbook and constructing graphs showing the corn production of Iowa or potato yield of Idaho comprised most of the work in such geography classes. It is little wonder that geography has been "shelved" and disregarded as meriting a permanent place in the secondary school curriculum.

Further evidence of the need for more geography came to light through place tests which were given to the same students mentioned above. The class is given an outline map of the United States and is required to locate the states as the instructor reads the individual states. Data indicates that only four per cent of the students located correctly all of the states. Forty-four per cent incorrectly paced at least 10

states, while twenty-seven per cent failed to locate correctly over one-half of the states.

The accompanying table shows, in percentages, the frequency with which the various states were incorrectly placed by the students. Only one state, Florida, was correctly placed by all students. Its location and shape, together with its importance as a winter resort, are largely responsible for it being well known. Texas was correctly located by all but one per cent of the students with California and Indiana being incorrectly placed by two per cent. The fact that a college freshman, and in one case a senior, incorrectly located their home state is certainly lamentable.

The state most frequently missed was Vermont with a per cent of error of seventy-three. New Hampshire and Nebraska followed closely, each being incorrectly located by sixty-six per cent of the students. It should be pointed out, however, that thirty-five per cent of those who missed New Hampshire and Vermont interchanged the two states. New Mexico and Arizona were frequently interchanged as were Alabama, Georgia and Mississippi. The frequency with which Nebraska, Kansas, Colorado and Wyoming were incorrectly located was due in no small degree to the same factor.

Further examination of Table I shows that only seven of the states were correctly located by at least ninety per cent of the students, ten were correctly located by eighty per cent, nineteen by seventy per cent, thirty by sixty per cent and thirty-nine by fifty per cent of the students.

It is, of course, admitted that the same results may not be obtained in other parts of the United States. Certainly the section of the country in which the tests are given would determine the distribution of errors. For example, should the test be given in Vermont, certainly that state would have been correctly located with almost one hundred per cent accuracy.

It is also admitted that location is only one phase of geography. However, it is an important phase and one that can be developed without a great amount of expensive equipment. The first step in the study of a city or a region is its location.

Tests similar to the one just described were also given but dealing with places of prominence in the Pacific theatre of war. Thirty-five per cent of the students were unable to locate at least one-half of the stations correctly. Only two students among the one hundred and eight who took the location test of the Pacific region were able to locate the twenty places correctly. These figures indicate a definite lack of awareness to locational geography in relation to current events and the future security of the world.

There needs to be, however, considerable caution exercised when stressing more geography in secondary schools. The average person's impression of the subject is too often unbalanced. Evidence of this is to be found in current magazines, newspapers and the mass of polar projections and "Air Age" maps now being published. The publications too frequently leave the impression upon those unacquainted with true georgraphy that new air routes, distances and times between one place

and another are the core of the subject matter. This is hardly what true geography has been or will be in the future.

Real geography is far more than a matter of names, and an understanding of flying time and directions. Geography concerns itself with all of those features, both physical and cultural, which affect man's adjustments to his natural surroundings. The continuous struggle of man to adjust his activities to climate, soil, and topography; to secure efficiently the natural resources of the land; to secure food, shelter and clothing; to find and hold markets and control trade routes; all are a part of geography and its significance in man's everyday life. The kind of surroundings leaves an indelible stamp upon the people who live in it.

Table I

The Frequency, in Percentage, with which the Various States were Missed by Students

State	Percentage	State	Percentage
Alabama	38	Nebraska	66
Arizona	57	Nevada	30
Arkansas	47	New Hampshire	66
California	2	New Jersey	46
Colorado	62	New Mexico	39
Connecticut	41	New York	29
Delaware	55	North Carolina	39
Florida	0	North Dakota	31
Georgia	29	Ohio	9
Idaho	36	Oklahoma	41
Illinois	5	Oregon	23
Indiana	2	Pennsylvania	26
Iowa	38	Rhode Island	41
Kansas	45	South Carolina	35
Kentucky	9	South Dakota	29
Louisiana	41	Tennessee	19
Maine	16	Texas	1
Maryland	57	Utah	40
Massachusetts	54	Vermont	73
Michigan	22	Virginia	36
Minnesota	30	Washington	14
Mississippi	44	West Virginia	38
Missouri	41	Wisconsin	28
Montana	35	Wyoming	52

Some Factors Which Enabled Europeans Successfully to Settle the American Forests

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To Europeans in the seventeenth and eighteenth centuries the eastern part of America was a wonderful forested "Eden newly sprung from the Ocean" yet at the same time a formidable challenge to exploration, conquest, and settlement. Most Europeans came from open countrysides and were poor men of the handicraft period when science and folklore were still much intermingled. But selecting from their total stock of knowledge, experimenting afresh, and learning from the natives, the colonists in time developed a complete system for survival in the forest and the setting up of civilization. American history entered a Wooden Age, when the forest was both major aid and major obstacle.

Travel and communication were a problem in the tangled primeval woods. Colonists solved the problem in part by using boats along the sunken Atlantic shoreline where bays and estuaries interfingered with the land, and along the big rivers that thrust into the continent toward the easy portages near the Great Lakes. They adopted the Indian dugout, made from whole tree trunks, and the canoe, made primarily of bark. When they had to travel by land they went afoot, following the elaborate network of Indian trails, or breaking trail, aided by Indian woodcraft. They crossed swollen streams by felling a tree across to make a "raccoon" bridge or by binding impromptu rafts with grapevines. While traders and soldiers found ways to use horses, emigrants used the European ox, which with its cloven feet was better adapted to pulling loads through marshes and among stumps and roots. Men learned to select routes by studying vegetation and soil and chopped out lanes, using blazes to indicate main and side roads. The corduroy road, made by laying logs side by side at right angles to the line of travel, became a commonplace road through bogs and bottoms.[1]

The backwoods developed a characteristic weapon, the long rifle. The musket of the early colonists, the Blunderbuss, and the Brown Bess were relatively useless. Short barreled and hard kicking, flaring at the muzzle, the musket was always inaccurate and short ranged and was therefore most effective when shot in volleys. Its days were numbered, for about the year 1500 Gaspard Kollner, a Viennese, had worked spiral grooves into the bore of a gun. By giving a rotary motion to the bullet, he gave it unprecedented distance and accuracy. The idea spread into Germany and Switzerland, where men formed corps of Jaeger rifle-

[1] Bartram, William, 1791. *Travels Through North and South Carolina.* Philadelphia; Belknap, Jeremy, 1813. *The History of New Hampshire,* Boston; Hall, B. R., 1855. *The New Purchase.* New York. The notes to this paper list only a few of the available sources.

men, and came with Protestant refugees to Pennsylvania. There backwoods smith experimented with bore, rifling, length of barrel, and native materials. By 1740 they had developed a native rifle weighing fourteen to twenty pounds, four to six feet long, with a stock of black walnut running clear to the muzzle. Fitted to the work of stalking the abundant game of the woods, it was relatively silent, economical in the use of lead and powder, light, strong, easily repaired, and—in a world of logs and branches—easily supported for aiming. It fed whole families and was essential in peace and war to all kinds of frontiersmen. At the start of the Revolution, which it helped win, exhibition shooters demonstrated its possibilities. At Lancaster a rifleman put eight consecutive shots into a two-inch bullseye sixty yards away. On Cambridge Common another rifleman hit a seven-inch pole 250 yards away.[2]

The leather shirt of the hunter, his moccasins, his habits in camping out, his lightweight nourishment of dried venison and cornmeal, his strategy in hunting wild animals, really a series of intrigues and ambushes—these came from Indian tutors. Applied to warfare against human beings, this whole pattern became the American style of fighting, of constant movement, applied woodcraft, surprise, and ambuscade, that European officers and soldiers had to master in order to survive.[3]

The most important task facing colonists was deforestation. They learned to select soil by noting the species of trees growing on it, the size and number. From the Indians they borrowed the technique of girdling trees, and they developed their own schemes for clearing land by felling and burning up the trees. While they developed many kinds of fences that used the abundant wood of the clearings, it was types of stake and rail fences, following patterns used in Sweden and the forested portions of central Europe, that came to dominate. The most notable was the Virginia worm fence, six to eight rails high, with stake and rider.[4]

The Dutch and English settlers in the seventeenth centuries had nothing but frame houses like those in the homelands. These required elaborate inventories of tools and the slow labor of splitting or sawing clapboards. Frame houses caught fire easily, bullets easily penetrated them, and in the southern colonies, where they were made of oaken clapboards, which warped, they were drafty. The style that came to house the generations on the frontier was the log cabin imported by Swedes, Finns, and Germans to the colonies on Delaware Bay. The cabin used the abundant wood, whole logs at a time, cheaply and quickly. It required no nails or other ironwork. It could be built with just one tool, the ax, If properly chinked, it was warm, tightening as the logs shrank. It

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[2] Burlingame, Roger, 1938. *March of the Iron Men.* New York and London; Randolph, Vance, 1931. *The Ozarks.* New York.

[3] Adair, James, 1775. *The History of the American Indians.* London; Kercheval, Samuel, 1850. *A History of the Valley of Virginia.* Woodstock, Va.; Rogers, Robert, 1769. *The Journals of Major Robert Rogers.* Dublin.

[4] Chinard, Gilbert, 1945. The American Philosophical Society and the Early History of Forestry in America. Proc. Am. Philos. Soc. 89:444-488; Mercer, H. C., 1929. *Ancient Carpenters' Tools.* Doylestown, Penna.

stopped bullets and fire arrows and was simply repaired. It served as the natural housing for a nation of poor backwoodsmen.[5]

While wild animals and plants supplied settlers with food, including tree sugar and the honey of European bees naturalized in hollow limbs, their basic foods were Indian corn and the Old World hog. Unlike European small grains, corn thrived in the semi-shade of girdled groves, competing with weeds and increasing many times for each kernel planted. Since the mature plant could be left standing in the fall, being harvested at will to feed human beings, livestock, and barnyard fowls, corn fitted flexibly into busy lives. And colonists learned from Indians a score of ways to use its grains, including pone and hominy.

Grass was scarce in the forest and stinging insects were abundant, and where cattle could not endure in the woods hogs found a plenty of nuts, acorns, roots, and tubers that made them grow corpulent. Besides, while a cow had only one calf a year, the razorback sow bore several litters. Razorbacks had long legs like greyhounds. They could gallop a mile and leap over rail fences, but they raised themselves without care. And once butchered, they served a dozen purposes in the household. Families felt the future was safe when they had all the pork they could eat. They were afraid when they could see the bottom of the pork barrel.[6]

Clearing the forest, splitting rails, chopping fuel, building the cabin all required the ax, and the backwoods evolved its own tool. The early colonists brought with them the European felling ax weighing about three pounds, a type virtually unchanged since Roman times. The handle was straight and round, the bit wide and flaring, the round poll so light that the axhead was unbalanced and wobbled in the stroke. In the coastal colonies blacksmiths developed axheads that were balanced. The poll grew flat, thick, heavier sometimes than the bit, and the bit lost its flare while gaining in cutting power as smiths learned to make the cutting edge by inserting steel strips and welding them. The head gained in weight up to seven pounds. The handle got longer, slimmer, took on an oval cross-section, curved so that the center of the cutting edge and the end of the handle were on the same plane. A bulb developd at the handle end to give the axman a firmer hold.[7] The American ax was the instrument that enabled the frontiersmen literally to conquer and exploit the forest, destroying it to make way for farming, or converting it into masts and boards, planks and bolts of cabinet wood.

The interaction of European and Indian culture amid the great forests of eastern America produced a unique backwoods civilization of canoeists, road blazers, hunters, scouts, railsplitters, cabin dwellers,

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[5] Johnson, Amadus, 1911. *The Swedish Settlements on the Delaware.* Philadelphia and New York; Shurtleff, H. B., 1939. *The Log Cabin Myth.* Cambridge, Mass.

[6] Force, Peter, 1836-1846. *Tracts and Other Papers, Relating Principally to the Origin, Settlement, and Progress of the Colonies of North America.* Washington, D. C.; Kirkland, Joseph, 1887. *Zury, the Meanest Man in Spring County.* New York; The Elias Kiser MSS. Indiana Historical Library.

[7] Mercer, op. cit.

and lumberers. A challenge and an opportunity for men working, the process of occupying and developing the forest was a common experience that unified the nation until about 1848. Thereafter the country split into North and South, the treeless and arid plains and deserts raised brand-new problems, the Machine Age began, and Americans faced a series of new adjustments to environment, ones not yet satisfactorily made.

The Buddha Outlier of the Mansfield Sandstone Lawrence County, Indiana

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The purpose of this paper is to describe and depict the relationships of a small isolated outlier of the pebbly phase of the Mansfield sandstone formation of basal Pennsylvanian age, resting deeply in the Mississippian system, located near the cross-roads hamlet of Buddha, Lawrence County, Indiana, some 10 miles or more east of the general outcrop of the Mansfield formation. Figures 1 and 2 have been prepared to show the geologic, topographic and geographic relations of the occurrence of the Buddha outlier of this basal formation of the Pennsylvania system so unexpectedly remote from the main body of the formation and so surprisingly different in its stratigraphic surroundings. The presence of this outlier in the Buddha locality, some seven miles southeast of Bedford, was called to the attention of the writer some years ago by T. M. Bushnell of Purdue University, but it was not until recently that the outlier was investigated.

The Buddha outlier is located about one-half of a mile north of Buddha in sections 9 and 10, T. 4 N., R. 1 E. It occupies in part an easterly extending spur of dissected upland and in part the northern edge of a small section of the sinkhole upland surface, representing the Mitchell plain of southern Indiana as developed on the upland divide between the deeply intrenched valleys of East White River and Guthrie Creek. (See Figs. 1 and 2.) The small section of upland sinkhole plain is approximately 700 feet above sea level and 200 feet or slightly more above the alluviated valleys of these streams. On the upland surface are scattered patches of waterworn gravels composed of bronzed chert and small geodes, showing in some of the shallow road-cuts. These gravels represent the Lafayette upland gravels occurring so widely in the unglaciated section of southern Indiana. Normally these gravels are in place at elevations between 700 and 800 feet in altitude. Perhaps some of the gravels of the Buddha locality represent redepositions, or are residual on the limestone plain which has been lowered somewhat by subsoil solution, especially those at altitudes less than about 740 feet. A hill in section 14, about two and one-half miles southeast of Buddha, reaches an altitude of 800 feet, as shown on the Bedford Quadrangle topographic sheet, and the Lafayette gravel in place is apparently 60 feet deep. In none of the gravels of the locality were white vein-quartz pebbles observed, though it is not uncommon for them to be present in many of the Lafayette gravel areas in southern Indiana. These gravels are mentioned here because it should be made clear that they are in no way to be confused with the Buddha outlier of pebbly sandstone.

The Buddha outlier of the pebbly phase of the Mansfield formation is a narrow strip of outcrop not exceeding 100 yards in width and ex-

tending nearly east and west for a distance of about one-half of a mile. (See Fig. 1.) It forms an undulating divide or ridge rising slightly above the general level of the upland plain of the Buddha locality. The maximum thickness of the remnant does not appear to exceed 20 feet. The base was not found exposed at any place, but it appears to be about 730 feet in altitude. The maximum altitude of the ridge does not exceed 750 feet. Exposures are numerous in the form of massive boulders or surfaces on the undulating ridge and numerous free boulders or blocks of various sizes occur along the hill-side edges of the

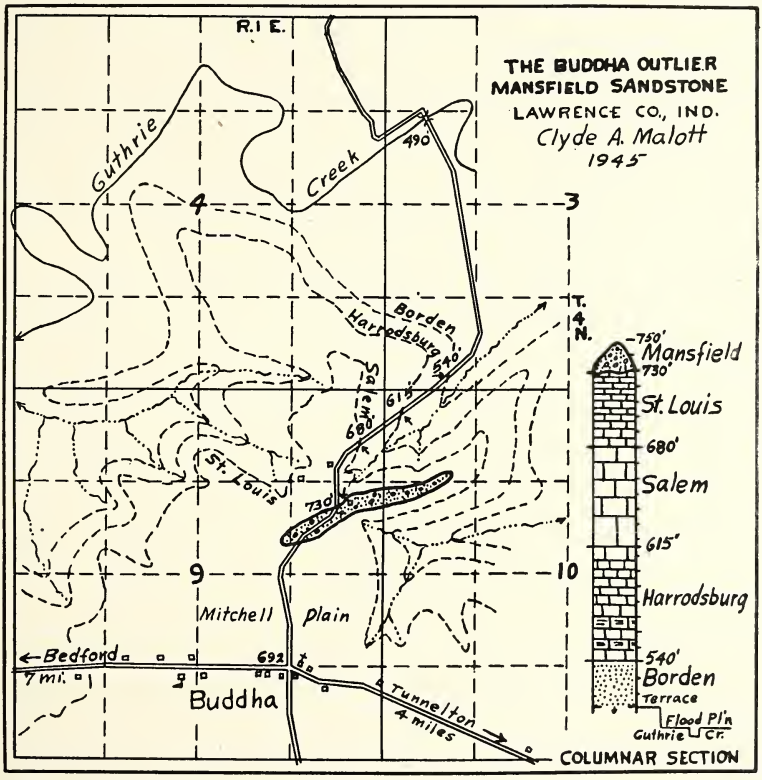

Fig. 1. Sketch of the Buddha outlier of the Mansfield pebbly sandstone showing its topographic and geologic relations.

formation, and numerous smaller pebbly boulders derived from the formation extend as float down the ravine running northeast from the deposit. No sections of the formation were available for study.

The formation appears to consist mostly of coarse quartz sand, grit and small pebbles, either loosely held together or firmly bound by iron oxide. Little local material derived from the surrounding formations appears to be incorporated in the formation, even in parts which appear to be close to the base. The sand is angular and subangular

with a minor amount of rounded grains, all of clear vitreous quartz. The grit, consisting of particles ranging from one-tenth to three-tenths inches in size, is dominantly angular and subangular, though some rounded fragments are not uncommon. The pebbles, either scattered through the sand and grit or massed in streaks in the cross-bedding of the of the formation, vary in size from small peas up to as much as one inch across. They are all quite rounded and the larger ones are elongated rather than spherical or subspherical. The grit and pebbles are composed of admixtures of opaque milky quartz, iron-stained quartz, pale-blue vitreous quartz, and clear vitreous quartz. A small quantity of dull, porous chert was observed in some of the hand specimens which were collected. The sand, grit and smoothed pebbles are rather poorly assorted, except in certain massed bands in the cross-bedding where the pebbles dominate. No true bedding was observed in any of the exposures. While the larger exposures are massive and difficult to break with a hammer, the formation does not appear to be thoroughly cemented. The cementing material is composed almost entirely of infiltrated iron oxide. The pieces of float composed almost entirely of pebbles break up readily when struck with a hammer.

The same description, perhaps with some variations, may be given to certain outcrops of the basal Mansfield sandstone formation elsewhere in Indiana, notably one and one-half miles west of Williams in the western part of Lawrence County, the Trinity Springs and Shoals localities in Martin Couty, and the Lafayette Spring locality east of Cannelton in Perry County. Since the basal Mansfield sandstone formation is the only Paleozoic formation known in Indiana with such a composition of quartz grit and quartz pebbles, it is only logical to conclude that the Buddha deposit is an isolated remnant of the Mansfield which once connected with the main body of the formation now many miles west down the dip from the severed and remote Buddha outlier.

The remoteness of the Buddha outlier from the main body of the Mansfield formation is only one of its unusual relations. It rests on the St. Louis limestone only 50 feet above the base of that formation. (See Fig. 1.) The base of the main body of the Mansfield formation down the dip in the western part of Lawrence County rests on various members of the Chester series, normally above the Cypress and Golconda formations which are respectively 395 and 440 feet higher stratigraphically than the position of the Buddha outlier on the lower part of the St. Louis limestone. This signifies that the pre-Mansfield erosion was as much as 440 feet deeper into the Mississippian system in the Buddha locality than it was in the area of the main body of the Mansfield in the western part of Lawrence County. The following formations with their normal thicknesses in the Huron locality were apparently eroded away before the deposition of the Buddha representative of the basal Mansfield formation:

Golconda	45 feet.
Cypress	35 feet.
Beech Creek	15 feet.

Elwren	35 feet.
Reelsville	5 feet.
Sample	30 feet.
Beaver Bend	15 feet.
Mooretown	20 feet.
Paoli	20 feet.
Aux Vases	5 feet.
Ste. Genevieve	115 feet.
St. Louis	110 feet (of the upper part).

No other locality in Indiana is known to have such a great stratigraphic range in the overlap of the base of the Mansfield sandstone.

The basal Mansfield where composed of or containing quartz pebbles, such as the Buddha representative, is largely confined to fillings in the more deeply eroded valley-like depressions in the underlying formations upon which the Mansfield unconformable rests. In the area of the eastern margin of the formation through Indiana the basal parts of the Mansfield are composed of its more normal sandstone phase or of a shale where it occupies its normal stratigraphic position. The pebbly phase

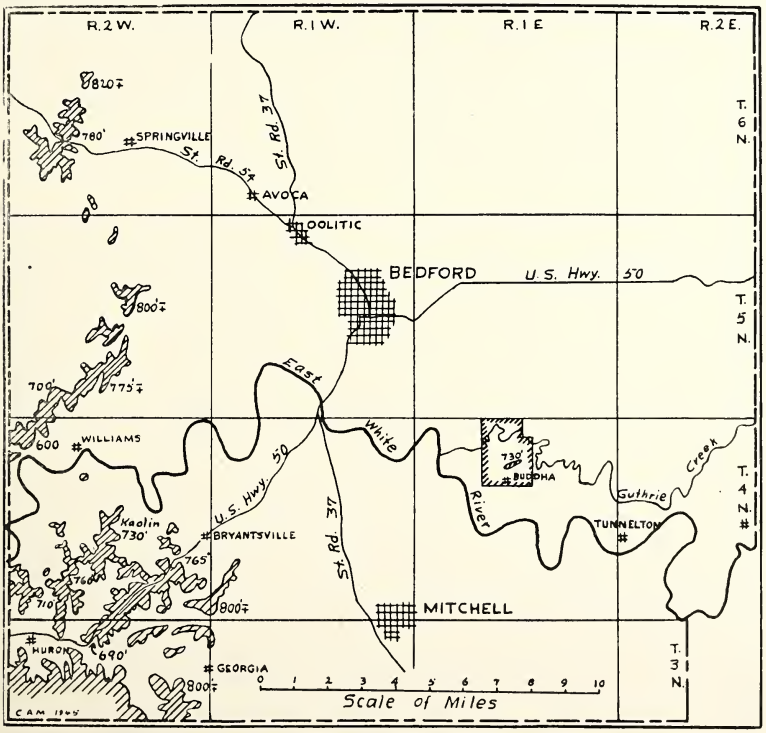

Fig. 2. Sketch of Lawrence County, Indiana, showing the position of the Buddha outlier in its remote relation to the ridge-crest outcrop of the basal Mansfield in the western part of the County. Figures express the variable altitudes of the Mansfield base.

is characteristic only of its base where it bites deeply below the normal stratigraphic position of the locality where such phases of the formation occur. Accordingly, the Buddha outlier is very likely a remnant of a Mansfield filling in a deep pre-Mansfield valley.

Some of the variabilities in the altitudes of the base of the Mansfield formation in the western part of Lawrence County are shown in Fig 2. The base of the eastern edge of the much eroded and dissected fringe of the main body of the Mansfield is at an altitude generally of about 800 feet, which is 70 feet higher than the altitude of the base of the Buddha outlier 10 miles away up the dip to the east. But the main body of the Mansfield in the southwestern part of Lawrence County has considerable variation in the altitudes of its base, especially west of the eastern fringe where data on the base are more readily available. The normal stratigraphic position of the base in Lawrence County is on the Cypress and Golconda formations, but in the Bryantsville-Huron area the base digs deeply below its normal stratigraphic position, in places coming below the Beech Creek limestone, and has a local relief in excess of 100 feet. On U. S. Highway, 50, one and one-half miles southwest of Bryantsville, the base rests on the Elwren shale at an altitude of 765 feet. At the old kaolin mines three miles west of Byrantsville, the Mansfield base of coarse, cross-bedded, massive sandstone is at the horizon of the Beech Creek limestone about 700 feet in altitude. Two miles southwest of the kaolin mines, the base of the Mansfield is at its normal position on the Golconda formation at an altitude of 760 feet. These altitudes not only represent the westerly dip of all the formations of some 30 feet per mile, but they show a variation in stratigraphic position as well.

It is in the locality west of Williams, however, that the Mansfield bites most deeply into the Chester formations. Here, a loose, pebbly phase of the Mansfield rests on or near the Beaver Bend limestone at an altitude of 595 feet, stratigraphically 120 and 165 feet respectively below the tops of the Cypress and Golconda formations. The loose, pebbly Mansfield has been dug or quarried for road material just north of the overhead bridge across the railway on State Road 450. Some redeposited iron-stained clay derived from the pre-Mansfield clay residue of the Beaver Bend limestone occurs in the base of the Mansfield in the quarry pits, along with some fragments of redeposited white kaolin. The pebbly phase of the Mansfield here occupies a pre-Mansfield valley as much as 150 feet below the nearby pre-Mansfield uplands. This old pre-Mansfield valley with its pebbly fill of the Mansfield formation extends west and southwest some four miles to the well developed, pebble-filled pre-Pennsylvanian valley in the Indian and Trinity Springs locality, mapped and described some years ago by the writer. It is not unreasonable to speculate on the possibility that the Buddha outlier is a remnant of the pebbly filling deposited in this same pre-Pennsylvanian valley.

It is quite certain that the Buddha outlier is an isolated remnant of the pebbly phase of the Mansfield deposited in a pre-Pennsylvanian valley trough which was cut deeply below the normal position of the

Mansfield base. It appears too deep, however, to be wholly accounted for by a pre-Pennsylvanian valley alone. It indicates severe truncation eastward of the underlying formations previous to the deposition of the Mansfield sandstone, and suggests that some aspects of the presence of a pre-Mansfield Chester escarpment, perhaps not greatly unlike the one which today lies just west of Mitchell between the main body of the Mansfield and the Buddha outlier.

Calcitic Pisolites Forming in Travertine Cascade Deposits

Robert R. Shrock, Massachusetts Institute of Technology

On a recent geological trip to the Southern Peninsula of Haiti, the writer came upon an active multi-terraced travertine deposit in which pisolites are abundant and appear to be forming at the present time. This brief article proposes to describe the conditions under which the travertine deposit is being built and to record data on the size, structure, and composition of the pisolites.

Location and Geology of Deposit

Sault du Baril, the local name given to the waterfall and cascades where the travertine is being deposited, is located a few kilometers inland from the coastal village of Petite Rivière some 20 kilometers west of Miragoane (Fig. 1). Here, at the head of a valley over a hundred meters

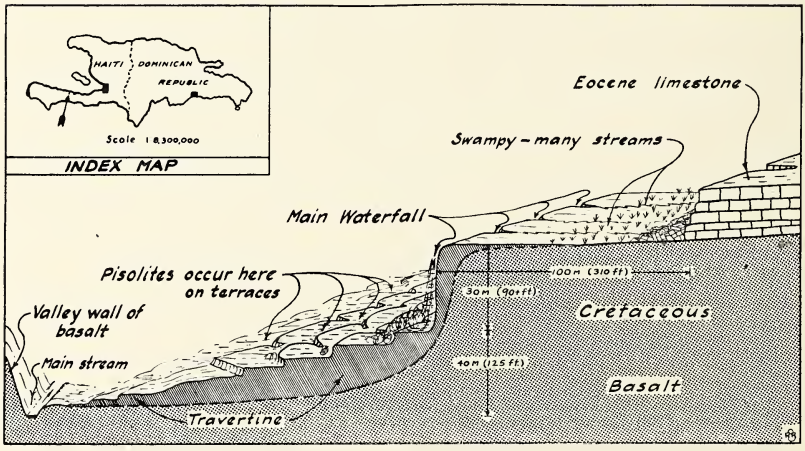

Fig. 1. Diagram of Sault du Baril showing relations of travertine cascade deposit to waterfall and underlying bedrock. The view is looking northeast. Pisolites occur in abundance on the terraced deposits at the base of the great waterfall.

deep, water heavily charged with calcium carbonate flows out along the contact between Eocene limestone and underlying Cretaceous basalt and, after a short course across a flat swampy terrace, plunges over the crest of a spectacular travertine deposit, in a dozen individual streams, and falls in a turbulent mist to the terraced deposits over thirty meters (100 ft.) below (Fig. 1). The fallen waters then gather themselves together into individual streams which flow swiftly and sinu-

ously downward, across an extensive ever-growing deposit of travertine, ultimately joining along the narrow valley bottom and thence flowing on to the sea near Petite Rivière.

Through the centuries, for the falls seems to have been in existence for a long time, the spring-born waters have been extending the crest of the waterfall until there is now a great wedge of travertine built against the upper part of the basalt valley wall (Fig. 1). At the foot of the almost vertical waterfall there is a broad, multi-terraced deposit of travertine which reaches down to the very bottom of the valley. This deposit seems also to have the shape of a wedge because it becomes thinner toward the valley bottom and at one point near the bottom a low knoll of the underlying basalt shows through.

The cool spring-born waters, saturated with calcium carbonate, almost immediately start precipitating their load as they become warmer and more turbulent. One sees many evidences of this early precipitation of calcium carbonate in the ashen-gray coatings on vegetation adjacent to the streams and in the heavy coatings left as shells around roots and tree trunks and around pieces of limestone lying on the surface. One sees further evidence as he walks or rides along the path following the crest of the falls. Here many small streams of swiftly flowing water follow narrow channels in travertine bounded by smooth "botryoidal" sides.

As one descends afoot the steep, crumbly face of the waterfall far to the left of the present flow, he sees everywhere great masses of sponge-like travertine containing leaves, twigs, branches, and even whole trunks of trees, all encased in a hard shell of rocky calcium carbonate. This situation is the one which often gives rise to the idea that the waters are "petrifying." On the gentler slopes and terraced segments around the base of the precipitous slope, one sees many tubular shells of concentrically stratified calcium carbonate lying about, doubtless the remnants of tree coatings from which the wood has disappeared.

Having attained the base of the precipitous part of the travertine deposits, one now has to thread a tortuous path through low bushes, ashen-gray with their limy coating, across many fragile steps and terraces of travertine which are literally growing out of the swiftly flowing streams which course beneath the bushes. After following a guide for perhaps a hundred meters, one comes out onto a broad, gently convex, somewhat terraced surface developed on friable travertine.

Here one has an excellent opportunity to examine this material called *travertine* which Webster's International Dictionary defines as "a white concretionary calcium carbonate, soft and chalklike to hard and semicrystalline, deposited from the water of springs or streams holding lime in solution." The definition fits the Haitian material perfectly. Here, at Sault du Baril, lime-laden waters have deposited such a mass of gray to light brown, friable to firmly cemented travertine—some as coatings and films on rocks and trees; some as loose or solid rock. Precipitation of the calcium carbonate takes place through loss of carbon dioxide which may be due to rise in temperature, aeration of the water during its turbulent fall and flow, or to the action of certain plants.

The result is this spectacular deposit which makes one think of a gigantic stairway leading to a stage with the curtain a 30-meter high, 100-meter long precipitous rock wall vertically banded with streams of shimmering white water losing themselves in mist at the base. The sight is well worth the 3½-hour horseback ride from the point where the river empties into the sea.

Occurrence and Nature of Pisolites

The pisolites are abundant in the friable gray travertine constituting the numerous terrace segments and inter-terrace slopes directly below the part of the waterfall where water was coming over at the time of our visit (May 11, 1945). Little if any water was flowing across the area where the loose pisolites were picked out of the friable travertine. The area seemed to be one of past rather than present deposition. It was assumed, from observations made at the time of the visit, that the concretions form at the base of the falls, where the water is broken into spray, and in the swiftly coursing waters which gather from the mist and find their way downward across existing travertine deposits. Bits of rock, leaves, twigs, etc., act as nuclei to start precipitation, and deposition once started continues as long as conditions are favorable. Many of the concretions have not been transported far, if at all, from the place where they grew judging from their shape and surface features; some, however, because of their spherical shape and polished surface probably were transported from the site of formation, though they could also

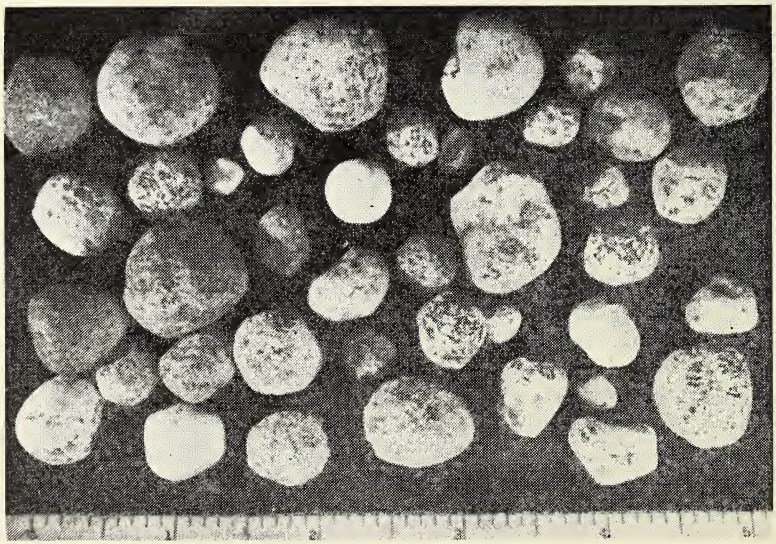

Fig. 2. Typical pisolites from the travertine cascade deposits at Sault du Baril, Haiti. The scale is in inches (1″=25 mm.).

develop those features by being rolled about in an enclosed basin of turbulent water.

The pisolites range in diameter from less than 2 mm. to more than 30 mm. Smaller irregular concretionary particles were seen; these, however, did not appear to be true concretions of oolite size but rather tiny aggregations of crystals. Some of the smaller pisolites are almost perfect spheres, many are spheroidal or ellipsoidal, and some of the larger are ovoid or irregular in shape because of rounded protuberances (Fig. 2). Generally the surface is hard and more or less smooth but occasional pisolites have a granular surface due to the porous, friable nature of the material.

Internally the pisolites are composed of concentric shells of denser, and stronger material separated by a zone of poorly cemented grains

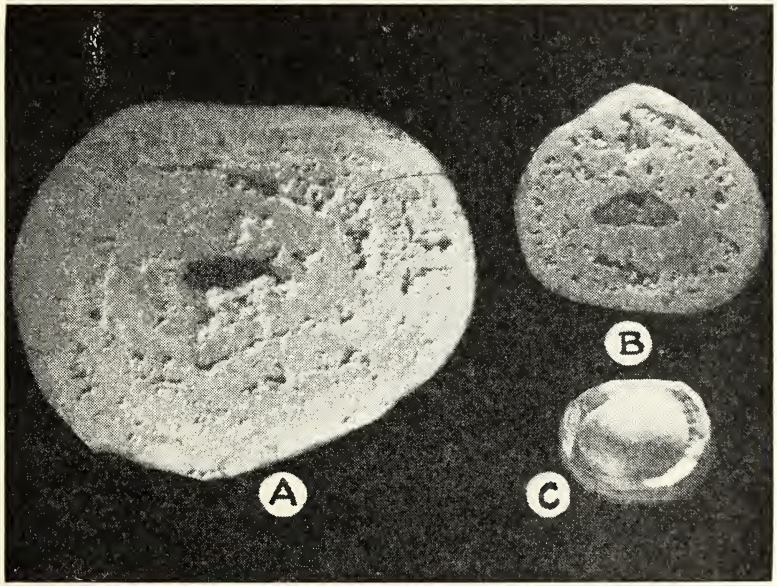

Fig. 3. Cross-sections of typical pisolites. A. Large, concentrically banded pisolite with hollow center. B. Medium-sized pisolite with a nuclear fragment of basalt. C. Small specimen with part of outer shell broken away. (All figures are magnified x 2.8).

which show no structure (Fig. 3). Each type of material was X-rayed and both were found to be calcite.* The difference in structure seems to be a matter of cementation and recrystallization. No radial structure was observed in any of the concretions.

Most of the pisolites that were broken or sectioned showed no visible nucleus but some did have a prominent cavity at the center suggesting

* I am indebted to Dr. H. W. Fairbairn, Massachusetts Institute of Technology, for making the X-ray analysis.

the possibility that there may once have been some sort of nuclear material. In one specimen (Fig. 3) a tiny bit of basalt constitutes the nucleus.

Under the conditions which prevail at the cascades, it is probable that any tiny bit of foreign matter—leaf, twig, rock fragment, or loose grain of travertine—would initiate precipitation and act as a nucleus around which a concretion could grow. Deposition once started would continue as long as conditions were favorable. All field evidence supports the view that the pisolites were formed as free, discrete bodies which later came to rest, in some instances after transportation, in the midst of granular travertine.

It seems altogether probable that with increasing age and burial the structure of the pisolite may change from alternating zones or shells of dense and porous material to a fairly uniform dense texture.

When the pisolites are dissolved in normal hydrochloric acid, there is violent evolution of carbon dioxide. After all chemical action has ceased the solution contains some gelatinous material. A small portion is organic and disappears on ignition. The remainder is iron oxide and silica.

Surficial Breccias Produced from Chemical Weathering of Eocene Limestone in Haiti, West Indies

ROBERT R. SHROCK, Massachusetts Institute of Technology

A common surface feature in limestone areas where chemical weathering is unusually active is a veneer of angular fragments of the rock that is being attacked. Under favorable conditions, on slopes and in channels and crevices where waters saturated with soluble salts circulate, the fragmental material may be cemented sufficiently to form a rigid, sheetlike mass. In this manner, certain ancient formations composed of angular fragments and commonly referred to as breccias may well have been formed. The purpose of this brief article is to describe a case in which a surface veneer of angular fragments—a potential surficial breccia—is being produced by chemical weathering of limestone.

During the spring of 1945, while conducting geological exploration in the Republic of Haiti, West Indies, the writer had an unusual opportunity to observe how limestones respond to tropical weathering at an elevation of 1500 to 2000 meters.

Rains on the high plateau around Mt. La Selle, where chemical weathering is so active, are seasonal, with two periods of heavy precipitation alternating with two periods of lighter precipitation or none at all. Initial drainage is largely downward and laterally through the limestones until the flow reaches a major valley trenching the plateau. Here, along the steep slopes, the water issues as springs. The features discussd below are related to the geologic work performed by the waters while they are flowing through the surficial debris and the limestone beneath.

The limestone involved in the weathering is a remarkably pure, white, rather dense and fine-grained rock of Eocene age which typically shows quite thick beds with only a few prominent joints. Close examination of the rock, however, reveals myriads of closely spaced but tight incipient joints, both straight and curved, which are characteristically enlarged during the weathering. There are several distinct stages in the weathering process and these will now be discussed.

In the initial stage the limestone surface is attacked most noticeably along the many tight joints and takes on the appearance of a slightly etched mosaic (Fig. 1A). In addition to the etching along joints, intervening blocks of the mosaic often develop a fretted or corrugated surface.

The second stage is reached when solution along joints reaches deeply enough into the rock that individual joint-controlled blocks stand almost completely free from the rock mass as a whole. Early in this stage it is not uncommon for numerous eyelets, pipes, and round cavities to develop along the joints and late in the stage the rock exhibits a cavernous nature on a grand scale (Fig. 1A).

The third stage is marked by partial or complete disintegration of the rock into surficial rubble composed of angular fragments that

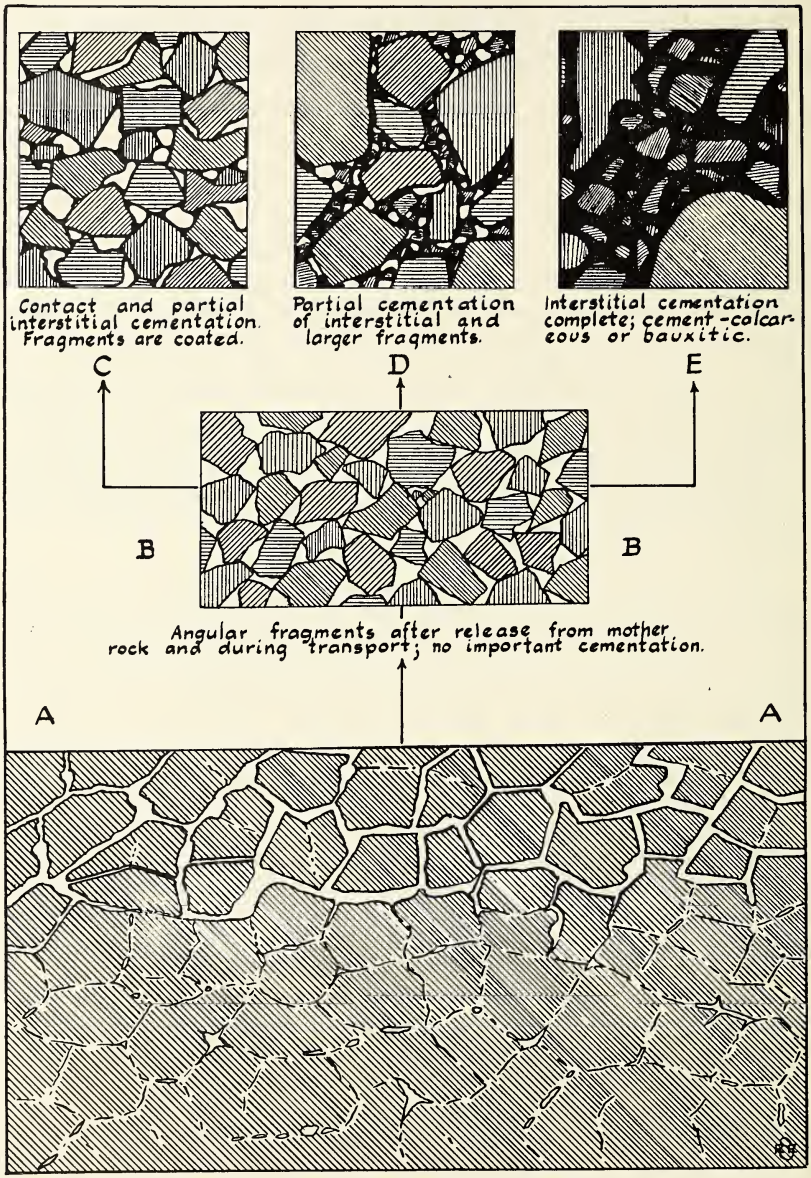

Fig. 1. Diagram showing how massive, incipiently jointed limestone is gradually disintegrated into polyhedral fragments with planar and curved surfaces. These angular fragments, after release from the mother rock, are transported down slopes mainly by sliding. When they come to temporary or permanent rest, circulating ground waters precipitate calcareous material in the interstices and cement the fragments into a rigid mass. Small fragments and residual soil may filter downward into the mass and fill a large portion of the interstitial space. In these cases also circulating ground waters may bring in calcareous matter and partially or completely cement the entire mass (D and E). These sketches are based on specimens and observations made in the field.

usually can be measured in inches. If the slopes are gentle, the rubble is almost certain to be cemented into a continuous layer before it moves far. If, on the other hand, the slope of the surface closely approaches or exceeds the angle of repose for the materials involved, the fragments may slide downward for considerable distances before coming to rest in a stable position. Then they too are likely to be cemented (Fig. 1A-B).

In the third stage the accumulation of angular fragments may develop either of two characteristic textures. In the simpler type, fragments of essentially uniform size are packed together loosely with maximum interstitial space. Such texture favors free and rapid circulation of ground water and since these waters are heavily charged with calcium carbonate, the fragments are quickly cemented together where they touch and are coated where their surfaces are not in contact. Continued deposition in the interstitial spaces ultimately produces a rock composed of angular fragments firmly cemented together by calcareous material which fills part or all of the interstices (Fig. 1C).

The more complex type of texture consists of a skeleton of large fragments, like those of the simpler type, with interstices filled by smaller angular fragments of several sizes which have sifted down through the larger interstitial openings. During subsequent cementation some of the smallest interstices are left unfilled whereas the larger are completely filled. The coating so commonly observed in the simpler type of texture is uncommon in the more complex type.

The fourth and last stage in the weathering process is that of extended or complete cementation. The resulting surficial crust or layer lacks any semblance of stratification and if incompletely cemented has the appearance of coarse concrete aggregate to which only a limited amount of fine aggregate and cement have been added for binding. The completely cemented rock breaks across fragment and cement alike and a surface has the appearance of a mosaic (Fig. 1E).

This general type of surficial breccia has not been recognized in any of the better known classifications of breccias[1], but the writer does not propose a term for it here pending further investigations.

During the weathering cycle just discussed, red residual earth, often with composition approaching that of bauxite, is left behind as the soluble limestone is dissolved. It may filter downward along with small limestone fragments into the enlarged joints of the country rock or into interstices of the surficial rubble and itself in conjunction with calcareous material act as a cement to bind the fragments into a rigid mass. Rock of this kind is not uncommon at various localities in Haiti and the writer has observed the same thing in Jamaica. In this type of breccia the white limestone fragments appear in some instances to float in the red bauxitic matrix. Woodring[2] has suggested *solution breccia*

[1] Bonney, T. G., On the relation of certain breccias to the physical geography of their age, Quart. J. Geol. Soc. London, **58**:185-206 (1902); Norton, W. H., A classification of breccias, J. Geol., **25**:160-194 (1917); Reynolds, S. H. Breccias, Geol. Mag., **65**:97-107 (1928); Twenhofel, W. H., *Treastise on Sedimentation*, 2nd edition, Williams and Wilkins, 1932, pp. 236-239.

[2] Woodring, W. P., et al., *Geology of the Republic of Haiti*, Dept. Public Works, Port-au-Prince, 1924, p. 109, 132, 134.

for the type here illustrated in figure 1E. In suggesting the designation he states (p. 109), "Cavities dissolved in the limestone are commonly refilled with soil and sediment that is recemented with calcareous material, producing a mass of rock that may aptly be termed solution breccia . . ."

Fragmental deposits of the type here described are probably not common in the geologic column because they are made where active solution is going on above the base level of erosion and are likely to be destroyed as the general terrane is reduced. Under abnormal geological conditions, however, as for example faulting, such a deposit might be buried and preserved. It would undoubtedly be designated some sort of limestone breccia but its origin might not be obvious. The characteristics of these unusual types of surficial breccia have, therefore, been considered worth recording so that they might be tested as a possible explanation of certain sedimentary breccias now preserved as rock in the geologic column.

Karst Features in Maya Region of Yucatan Peninsula, Mexico

Robert R. Shrock, Massachusetts Institute of Technology

It is the purpose of this brief article to discuss a few interesting karst features of the recently elevated, low limestone plateau which constitutes the northern part of the Yucatan Peninsula (Fig. 1). The features are located at and near the ancient Maya cities of Chichen Itzá and Uxmal. The observations on which this article are based were made during the spring of 1944 while doing geological reconnaissance in northern Yucatan. The writer was accompanied by Dr. Walter L. Whitehead, Massachusetts Institute of Technology, with whom he was fortunate to discuss the subject matter presented here.

Nature of Surface.—The peninsula of Yucatan has special interest for the student of geomorphology because of its youthful stage in the subterranean drainage cycle. It is a recently elevated plain, developed on fairly soft, flat-lying, chalky limestones of late Tertiary age, which rises gently southward from the Gulf of Mexico, where it stands only a few tens of feet above sea level, to over 500 feet above sea level in the jungle country of northern Campeche and northwestern Quintana Roo (Fig. 1). The region to be discussed in this article is probably not over 150 to 200 feet above sea level except for the prominent northwest-southeast trending ridge a short distance north of Uxmal (Fig. 1). There is a very interesting karst plain on the southerly backslope of this ridge,

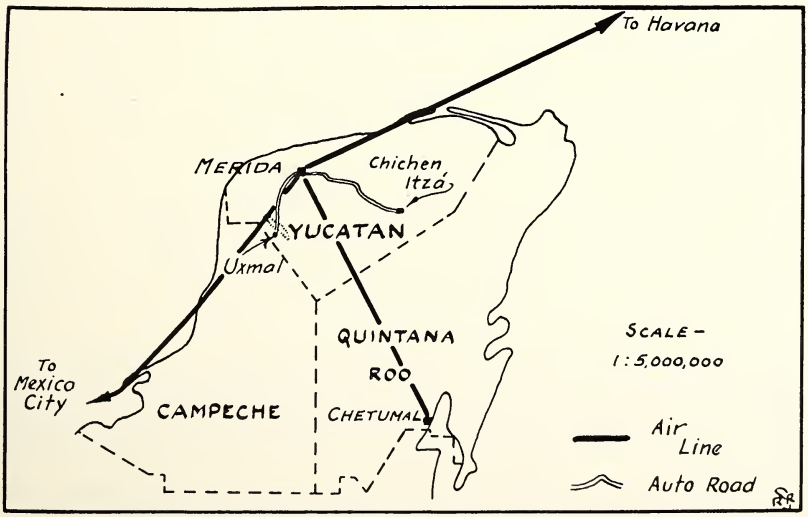

Fig. 1. Outline map of Yucatan Peninsula showing cities and towns mentioned in text.

which appears to be a fault block tipped to the south and scarped on the north side. Red residual soil has washed from this plain through gullies in the crest of the ridge and has been spread out on the north side of the scarp in the form of red alluvial fans which are quite apparent from the air. There is also an abundance of small caves and sinks in this same ridge. These have been very interestingly described by Mercer (1896), who explored a number of them in search for remains of aboriginal culture.

Between Mérida and Chichen Itzá to the east and Uxmal to the south, there is a gentle undulating surface of isolated and interconnected shallow basins of solution separated by low rounded knolls and ridges of limestone. Morris (1931, p. 2) aptly described the surface when he wrote as follows about an automobile trip from Mérida to Chichen Itzá "We moved as upon the back of a great measuring worm, now up, now down across the alternate sequence of swales and hummocks." Many of the depressions have a thin accumulation of red residual soil derived by solution from the surrounding limestone and concentrated in the lower part of the basin through surface wash. When viewed from the air, the red soil areas have a pattern like that of a jig-saw puzzle (Fig. 2). The actual area covered by soil never exceeds 50 per cent

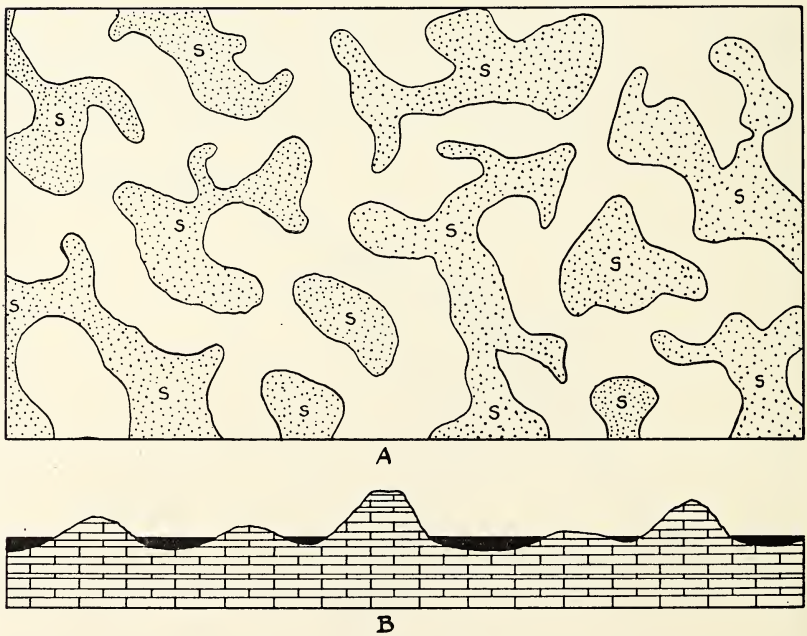

Fig. 2. Karst topography in Mérida region. A. Ground plan of soil-covered basins (s) and intervening ridges as seen from air and ground; the area is about one-half mile wide and one mile long. The area of red soil varies from 10%-50% of the total surface and the soil itself is rarely over five feet thick. B. Cross-section along bottom edge of A showing basins and ridges. The limestone ridges range in height from 1 to 50 feet and usually are covered by rubble.

of the total surface area and probably averages nearer 25 to 30 per cent. No soil deposits greater than five feet in thickness were seen.

There are no continuous channels or surface drainage. Water which falls washes down the bare limestone slopes, carrying to the bottoms of the intervening depressions whatever residual soil has accumulated in the crevices of the weathered rock, and then sinks through the porous residual soil mantle into the limestone beneath. The crevices and holes into which the downward moving water flows are not commonly conspicuous, but at a few places well-like sinks called *cenotes* have developed as a result of subterranean drainage and subsequent collapse of the cavern roof. It is an interesting fact that these cenotes do not lie in the center of shallow depressions, as they should if they represented outlets for sinkhole drainage, but rather on flat limestone surfaces.

The most notorious of the cenotes is the celebrated "Sacred Cenote" at the ancient Maya city of Chichen Itzá, but there are many other equally interesting ones in the general Mérida region. The writer counted a dozen circular ponds scattered over the karst plateau southeast of Mérida en route by plane to Chetumal and these are presumed to be cenotes similar to those seen on the ground. Brief references to some of the better known of these cenotes are made by Berlin (1898), Schenck (1906), and Willard (1926), who refer to them incidentally in discussing various aspects of the Maya civilization which flourished in the Yucatan region many centuries ago. Mercer, in his work on the hill caves of Yucatan referred to on a previous page, shows by diagrammatic cross-sections the relations of a number of cenotes to the underground caverns which he explored.

Vegetation.—A dense, almost impenetrable jungle of vines, bushes and low trees covers the Yucatan plateau except where the inhabitants have cleared the land for cultivation. Corn is the usual crop raised on the less rocky red soil areas and henequen (sisal), the chief crop of commerce which is cultivated for its hemplike fibre, flourishes on the rocky slopes.

In southern Yucatan and northwestern Quintana Roo the dense jungle, in which is the heart of the chicle country, consists of hilly areas of large, coarse-looking green trees separated by irregular flat tracts of finer textured, lighter colored vegetation. It was later learned that the zapote trees, which are the source of the gum chicle, prefer the rocky hills whereas swamp and marsh vegetation cover the lower flats where the soil is deeper. Karst topography borders the chicle country on the northwest and may also be present beneath the heavy jungle growth but this could not be determined from the air. It was learned, however, that the soil is thicker as one travels southeast from the Uxmal region.

Description of Cenotes (Natural Wells)—The cenotes, which appear to be scattered over the Yucatan plateau without a definite pattern, are vertical solution tubes which have been greatly enlarged particularly in the equatorial plane by slump and collapse. The early shape of a typical cenote is that of an upright brandy glass without the stem;

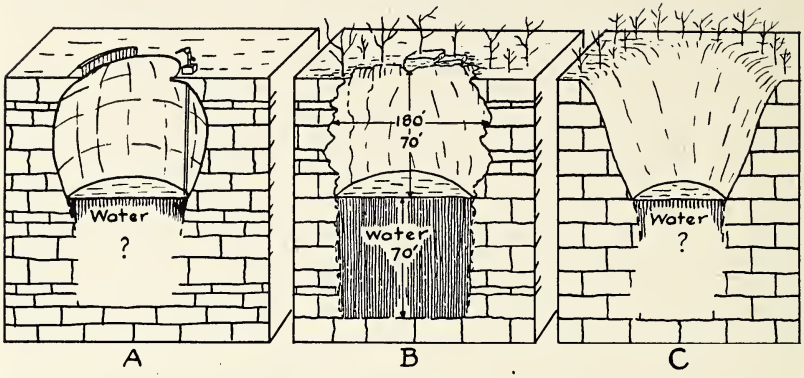

Fig. 3. Cenotes. A. A jug-shaped cenote at Libre Union west of Chichen Itzá. It is about 60 feet deep and 50-60 feet across. Water is pumped from the pool in the bottom to supply the village. The depth of the water could not be ascertained. B. Sacred Cenote at Chichen Itzá. The well has an elliptical opening and the brink overhangs to some extent. The outwardly curved wall has prominent encircling ribs and grooves produced by differential weathering of the flat-lying chalky limestone strata. C. Bowl-shaped cenote observed along the road to Uxmal south of Mérida. The depth appeared to be about 70 feet and the pool in the bottom fairly small. The depth of water was not determined. All diagrams are exaggerated vertically about twice.

i.e., smaller at the surface opening than half way down, and rounded bowl-like in the bottom (Fig. 3A). If the entire rim collapses, the shape is roughly cylindrical (Fig. 3B). Outward migration of the rim produces a bowl-shaped basin with the pool typically occupying most of the bottom (Fig. 3C). Several cenotes of the last type, with circular pools in the bottom, were observed along the road from Mérida to Uxmal.

The local inhabitants, descendants of the ancient Maya, have long depended on the cenote pools as a source of water, hence the name "natural well," and archeologists (Morley 1925, p. 65-66; 1936, p. 622) have concluded that the great Maya cities were located near cenotes for this reason. At the little village of Libre Union, on the road from Mérida to Chichen Itzá, there is a typical cenote about 50-60 feet across and about 60 feet deep. Water from the pool is pumped to the brink and is used locally (Fig. 3A).

Early in 1944 the writer saw a cenote similar to those of Yucatan on the flat karst plain east of Ciudad Trujillo in the Dominican Republic. This feature was described on the spot in the writer's field notes as follows:

"At 37 kilometers east of Ciudad Trujillo, on the north side of the highway, is a remarkable jug-shaped sinkhole known locally as the 'Indian Well' where, it is reported, the ancient inhabitants of this part of the island used to come for water. The cavity is about 25 meters deep, 15 meters in diameter near the bottom and perhaps 10 meters across at the surface opening. Stalactites hang from the walls which flare out

toward the bottom. At the time of our visit (Feb. 4, 1944) a pool of water covered perhaps half of the bottom of the sink.

"Indian Well and the numerous shallow sinkholes observable from the highway between Ciudad Trujillo and San Pedro de Macoris indicate extensive subterranean drainage on the elevated limestone bench along the coast."

The most famous of the Yucatan cenotes is "Sacred Cenote" or the "Well of Sacrifice" in the ancient Maya city of Chichen Itzá. According to archeologists (Morley 1925, p. 80-81; 1936, p. 622 and pls. XVI and XVII), young maidens were hurled into the well in times of great national necessity as living sacrifical victims. At the same time that the girls were thrown in, the Itzá people, who lined the brink during the ceremony, cast their prized possession after her, presumably with the hope of appeasing the gods. These possessions included numerous kinds of jade ornaments, gold and copper bells and rings, carved bones, wooden weapons and pottery.

Many of these articles were recovered about 40 years ago by dredging and are now on display at the Peabody Museum of American Archeology and Ethnology at Harvard University. A detailed description of the dredging operations and of the objects recovered from the bottom muds, which lay beneath over 60 feet of water, will be found in T. A. Willard's interestingly written "The City of the Sacred Well" (The Century Co., New York, 1926).

The Sacred Cenote is about 180 feet across at the top, somewhat larger at about half-depth, and generally cylindrical to the water's edge (Fig. 3B). The water surface of the pool is 65 to 70 feet below the rim of the cenote and the water is reported to be 70 feet deep and never to vary in level. Water level in the second cenote at Chichen Itzá is also about 70 feet below the surface but its depth does not seem to have been determined.

Geomorphological Significance of the Cenotes—The water table at Chichen Itzá stands at about 70 feet below the limestone plateau, but the elevation of the bottom of the cenote (about 140 feet below the surface) is not known. Concerning the depth of the cenotes, Morley (1936, p. 591) states, "The cenotes and modern wells vary in depth directly with the increasing elevation of the land as one withdraws from salt water, from only a few feet at the coast to about 100 feet in the interior. The level of the subterranean water table, however, always remains the same." It has been reported that no salt water is encountered in the cenotes except immediately adjacent to the coast where sea water mingles with fresh water in some of the sinks.

The elevation of the bottoms of the Yucatan cenotes has special significance for the following reason. Accepting the conclusion that the Yucatan Peninsula has recently been elevated, it follows that if the bottoms are now below sea level or above by less than the amount of uplift, subterranean drainage was active at elevations lower than the present water table. This does not mean, necessarily, that the under-

ground features resulting from solution were formed below the water table of the time. It is quite possible that these features were made during the part of the Pleistocene when sea level and water table both were lowered. Precise data on surface and subsurface elevations will have to be obtained, however, before any definite statement can be made about the level at which subterranean drainage developed.

Archeological Interest—The karst plain of Yucatan has special archeological interest because it is one of the regions where the Maya civilization attained a high state of development. Its sparse soil supported a community large enough to raise the great pyramids and temples that are today in partial ruin and the underlying limestone furnished the building materials for the structures. Water used in construction, as well as for domestic purposes, must have come from the natural wells because there seems to have been no other natural source of supply and no evidence remains to conclude that the Maya ever employed catchments and cisterns for water storage.

The archeology of the Yucatan Peninsula has been investigated in considerable detail and has been discussed in many publications but little about the geology has found its way into print. Since the life of the ancient inhabitants was so closely related to the karst features of the terrane, study of the geology offers a very worth-while field of investigation and should be encouraged.

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Sedimentation and Wind Action Around Volcan Parícutin, Mexico

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During a recent visit[1] to the well-known active volcano, El Parícutin,[2] southwest of Mexico City in the state of Michoacan, the writer was impressed by the important role the wind was playing in the redistribution and ultimate deposition of volcanic ash blown out from the active crater. This article proposes to discuss briefly certain aspects of the wind action and some of its geological implications.

Nature of eruption. During a typical eruption there is a great column of ash-laden gas above the 1,500-foot high cone (Fig. 1). The column, composed of successive outbursts, frequently reaches upward many thousands of feet before losing its identity through disruption by high-altitude winds. These wind currents, blowing across the column in various directions, spread the ash in an extensive triangular cloud. Ultimately the ash falls to earth from this cloud, covering the entire surface with a gray or gray and black mantle (Figs. 2 and 3).

Nature of Surrounding Terrane. Upon leaving Uruapan to visit the volcano, one travels for miles across a gently rolling countryside covered by a mantle of gray and gray-black ash strongly reminiscent of a heavy snowfall in northern latitudes (Fig. 2). The trees and shrubs are heavily weighted down with ash, sharp hills and the rough surfaces of geologically recent lava flows appear much smoother because of the ash mantle, and stream courses are so choked with ash that the water frequently has been forced out of its old channel and made to follow a new one. These recently cut ravines, some over ten feet deep, reveal excellent sections of beautifully graded and stratified ash, mostly black in the coarser basal portion of layers and lighter gray in the finer grained upper part. The old roads have long since been lost under the ash and the provisional automobile trails wander over the ash flats with regard only for attaining some objective in the distance—a situation somewhat like that on the sand flats of southeastern United States.

Wind Action Around and Near Volcano. During the afternoon on the day the visit was made, the surface winds were not strong but there was enough turbulence that one had to protect his eyes and nostrils from the impalpable dust which seemed to fill the air at times even on the windward side of the volcano. On the leeward side there was a

[1] The visit was made on May 12, 1944. Dr. Walter L. Whitehead, Massachusetts Institute of Technology, accompanied the writer and deserves a vote of thanks for several suggestions.

[2] El Parícutin, Estado de Michoacan, Universidad Nacional Autonoma de Mexico, Instituto de Geologia, Estudios vulcanologicos, Mexico, 1945.

heavy ashfall, judging from the height and size of the columnar cloud above the crater (Fig. 1).

About 9:30 P.M., perhaps an hour and a half or two hours after the sun had set and the surface of the ash had cooled, there arose a strong wind blowing toward the volcano. This wind, apparently produced by the strong updraft of heated gases in the column over the crater[3] (Fig. 3), finally became so strong that the air was filled with

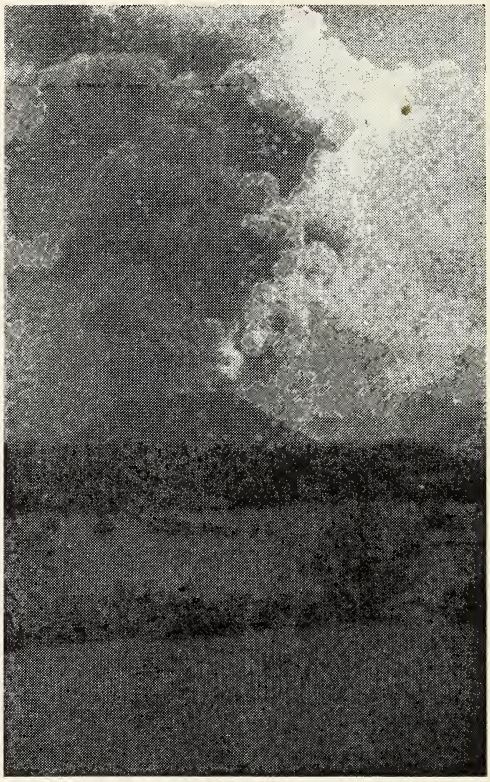

Fig. 1. View of El Parícutin, May 12, 1944, showing typical ash-laden column above the crater.

ash swept up from the surface. The sight of the volcano, made spectacular by the fiery trajectories of incandescent bombs, was blotted from view and the visitors had to retrace their steps to the nearby village. These strong nocturnal winds undoubtedly have been partly responsible for sweeping the ash off much of the surface of the recent

[3] It is probable that there also was some convection over the internally incandescent lava tongues which have flowed out from the volcano, but this is considered unimportant when compared to the strong updraft above the crater.

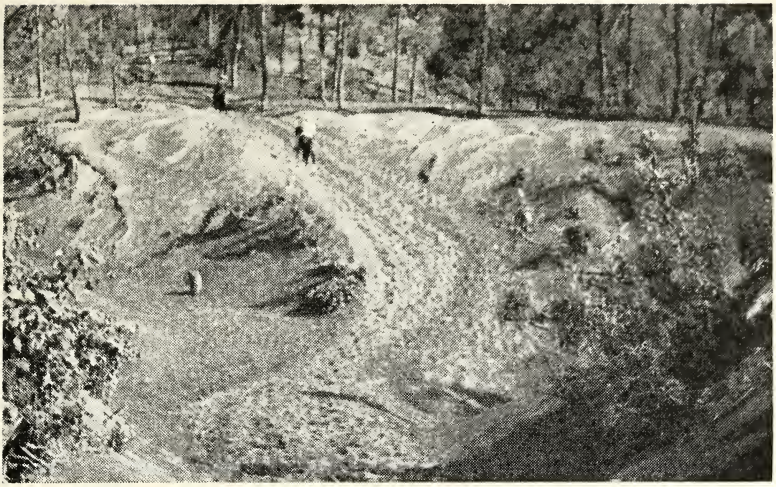

Fig. 2. View of heavily ash-covered terrane along the trail to El Parícutin from San Juan de los Conchillas, May 12, 1944.

lava flows and depositing it in the lower parts of the terrane. Diurnal surface winds have also probably played an important part in this same process.

Farther away from the volcano, where the eruptive activity does not interfere with normal meteorological conditions, local and regional winds are constantly disturbing and redistributing the newly fallen ash. In this process the ash is blown off the higher and more exposed slopes and hilltops and ultimately deposited in lower, more protected

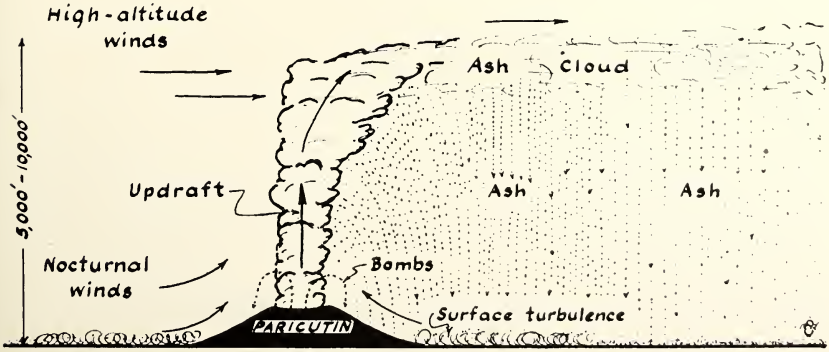

Fig. 3. Diagram showing high-altitude winds blowing ash-laden gases away from volcano and surface nocturnal winds blowing toward the volcano, the latter as a result of the strong chimney-like updraft over the crater.

areas (Fig. 4). Ripple-marked surfaces seen on some of the ash flats attest local transport. Small whirlwinds, a few tens of feet across and a hundred or so feet high, are a common sight on the white ash flats in the early afternoon. Fourteen of these were observed at once in an ash-filled basin between low, bare-rock hills. Their general effect must be to level exposed ash deposits.

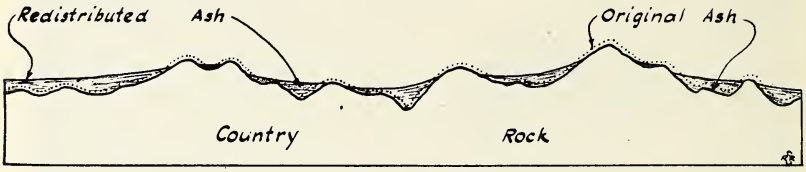

Fig. 4. Diagram to show how original ash mantle is eroded and redistributed by wind action, resulting in denudation on higher more exposed places and deposition over lower, more protected areas, with general smoothing of terrane.

Summary and Conclusions. It is here suggested that wind action around an ash-erupting volcano is an important force in redistributing the ash and forming extensive ash flats surrounding volcanic peaks. Farther afield prolonged wind action is believed to affect widespread redistribution of ash with a general tendency to level the terrane by transporting material from higher to lower places. Torrential rains are also undoubtedly important in locally transporting ash, but the water soon loses its competency by sinking into the highly porous material.

It is suggested that wind action, like that which may be observed today in the vicinity of El Parícutin and farther away, may well have played an important role in forming the extensive ash plains of the central plateau of Mexico. Furthermore, it seems altogether likely that wind was an important redistributor of ash during past epochs of volcanic activity, especially before there were any land plants to protect the surface materials.

Sand

Ernest Rice Smith, DePauw University

In retracing some of the "footprints in the sands of time," my mind goes back to a conversation some two years ago with my aunt, then eighty-four years young. She referred to "maple sand," a common "pest" to the maple-syrup makers in Vermont. The implication was that this "sand" had come up as sand from the soil through the circulatory system of the maple tree and then settled out in the boiling down of the sap. The resulting argument, as in so many cases, was based merely on lack of definition of terms. There *is* such a thing as maple sand, but it has *not* come up as sand from the soil. It's a fine, white, crystalline, rather impure calcium malate which, because of its relative insolubility (as compared with sugar) precipitates before the sugar in the syrup and sugar making. The solubility of calcium malate at 0°C. is 0.812 gm. per 100 cc. of water as compared with a solubility of sucrose, under the same conditions, of 179 gms. This relative difficulty of solution of the calcium malate as compared with sugar will explain the feeling of the maple-sugar maker that it is as insoluble as sand and the resultant naming of the material, "sand." Examination of two specimens of maple sand indicates a material much finer than what is usually called sand.

Table I. Grain Analyses of Two Specimens of Maple Sand[1] According to Modified Wentworth Classification. (Table II.)

	Coarse Sand ½ mm. plus	Fine Sand ½ mm.-1/16 mm.	Silt 1/16 mm.-1/256 mm.	Clay less than 1/256 mm.
a.	5.7%	8.5%	22.8%	62%
b.	3.5%	3.5%	45.5%	48%

Biologically the term sand is also applied to various kinds of material in the human body, such as brain, kidney, bladder, and prostate "sands." "Brain sand" is composed of irregular, agglutinated, yellowish or reddish grains found either in the pineal body or areas of toxoplasmic disease in the cortex.

Although pineal bodies do not consistently show brain sand, there is no positive evidence that its presence indicates a diseased condi-

[1] Specimen a, courtesy of the Vermont State Department of Agriculture; and, b, courtesy of Bradley St. John, Fairhaven, Vermont.

tion. In fact, when present, this pineal sand may perform a valuable function, if an x-ray photograph of the brain is necessary to determine the presence of a brain tumor. Such a brain tumor may not show up plainly on x-ray photographs, but, if present, it will frequently displace the pineal body from its normal median position. The pineal sand will photograph, thus showing the displaced position of the pineal body, and therefore indicating the side on which the brain tumor has developed. Kaufman (20, p. 1819) describes the pineal sand as mulberry-like reddish bodies composed of calcium carbonate with a layered albuminous material of unknown origin. Although it is not indicative of any specific disease, the amount of pineal sand frequently increases from about eight years.

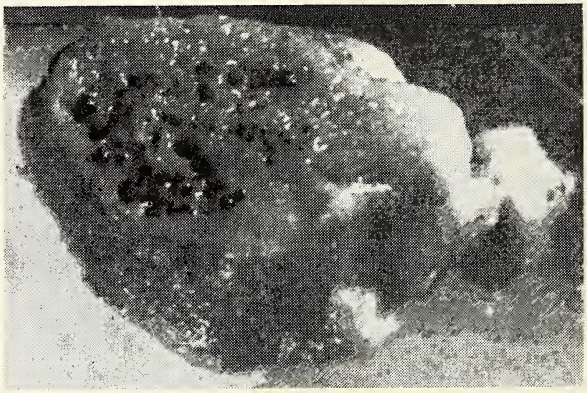

Fig. 1. Photo Showing Human Pineal Body with a Section Removed from the Left Side, Exposing Pineal Sand. Courtesy of J. W. Papez, M.D. Photo, K. V. Palmer.

Brain sand in the cortex is positive evidence of various types of diseased condition in the brain—*tuberous sclerosis, toxoplasmosis,* possibly as *sclerotic* patches on the cerebral blood vessels.

The balancing mechanism of vertebrate animals contains *otoliths* (*otoconia* in the human body) frequently of the size of sand grains suspended in the inner ear. These bodies, either single or multiple granules (usually calcium carbonate) in a gelatinous mesh, are suspended in the endolymph in contact with the free ends of hairs projecting from the maculae, sensory areas of the utricle and saccule of the membranous labyrinth. Because of their size these granules frequently fall in the range of sand (Table II) and in the dog-fish shark *(Squalus acanthias* L.*)* actual grains of sand are used in this balancing mechanism. These grains are drawn down into the saccule through the endolymphatic duct. An examination of the grains from the balancing mechanism of one dog-fish,[2] which may or may not be typical, gives the following distribution of grain-sizes: between 28 and 297 microns, with the finer

[2] Obtained through the interest of Professor W. E. Martin.

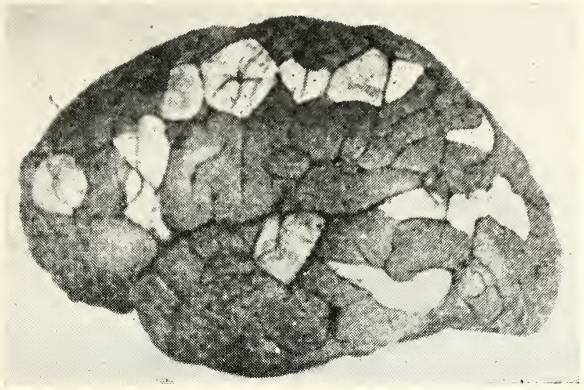

Fig. 2. Copy of "Lateral Surface of the Brain Showing the Distribution of Patches of Tuberous Sclerosis." (18, p. 234)

sizes the more abundant. In the Wentworth classification of clastic grains (Table II), 11/20 grains would be silt; 6/20, very fine sand; 3/20 fine sand.

Kidney and bladder sand may be found in the kidneys, pelvis, urinary bladder, gall bladder, urethra and prepuce. The bodies range in size from very fine sand up to a diameter of several inches. The most common components according to Kaufmann (20, p. 1410) are: (a) uric acid or urates. The urate stones are the most common, moderately hard, with a soft granular or nodular surface, yellowish brown or reddish brown color, laminated structure; (b) calcium oxalate. These stones are small, warty, colorless or stained with hematin. They may be composed of alternate layers of calcium oxalate and urates; (c) calcium or ammonium magnesium phosphate. These are formed in alkaline urine.

Fig. 3. Copy of Section of the Cerebellum Showing Small Cavities Encrusted with Calcium Carbonate. (Nissl's Stain, Low Power.) (18, p. 241)

Prostate sand. Cross-sections of prostates of older men contain almost constant yellow, brown or black granules from the size of grains of snuff to that of a pea or larger. On examination of the prostate gland they may be felt through the rectum. (20, p. 1520)

Geologically, sand may be defined as fragmental rock material intermediate in size of grain between gravel and silt. The British classification as proposed by Boswell (1918) (27a, p. 108) differs from the American geologic practice as proposed by Wentworth. (50, p. 507)

Table II. Wentworth Classification of Clastic Particles on the Basis of Grain Size.

Boulder	256 mm. plus
Cobble	256-64 mm.
Pebble	64-4 mm.
Granule	4-2 mm.
Very coarse sand grain	2-1 mm.
Coarse sand grain	1-½ mm.
Medium sand grain	½-¼ mm.
Fine sand grain	¼-⅛ mm.
Very fine sand grain	⅛-1/16 mm.
Silt Particle	1/16-1/256 mm.
Clay particle	less than 1/256 mm.

In this classification, then, all sedimentary grains 1/16-2 mm. are in the sand range. In the opinion of the writer the Wentworth classification is a backward step as compared with the British in that it is based so largely on common fractions instead of decimals, the fundamental basis of the metric system.

In addition to the British and American geological classifications, The International Society of Soil Scientists have their own classification which with slight modification is shown in Table III.

Table III. Classification of Soil Grain Sizes as Adopted by the Int. Soc. of Soil Scientists. (40, p. 12)

Coarse sand grain	2.0 -0.2 mm.
Fine sand grain	0.2 -0.02 mm.
Silt	0.02-0.002 mm.
Clay	less than 0.002 mm.

Relation of Grain Size to Origin

A recent paper by Keller (22, p. 215) reports that a study of 700 samples from Pacific coast dunes and beaches, 370 samples from inland dunes as far east as Dunes Park, Indiana, and 272 samples of the St. Peter sandstone in Missouri, the Tensleep and Wyopo sandstones in Wyoming and the Navajo sandstone in Utah gave the following results: Beach sands are approximately four times as coarse as corresponding dune sands. The inland dunes seem to be more variable in coarseness

than the dunes near the beaches. Comparison of the St. Peter, which has been frequently considered of eolian origin, with the beach and dune sands indicates definitely that the St. Peter had a beach origin.

Composition of Sands

Although commonly sand is thought of as being composed of quartz, it is considered technically as being of no single composition, but as being of a definite range of grain size as determined by the specific method of classification used. In general, it has been assumed that the number of minerals in a sand or sandstone decreases with distance from the source. Shaler reported (43) that "an unusually pure beach sand is found at West Palm Beach, on the Atlantic Coast of Florida (probably Palm Beach, E. R. S.), nearly everything but quartz being eliminated." Russell (41, p. 1347), however, in his study of samples of Mississippi River bottom sediments from Cairo to the Gulf concludes that the selective destruction of the "less resistant" minerals (either chemically or physically) has been generally overestimated. The hypothesis, that the presence of "less resistant" minerals in a sand indicates a nearby source, has no factual basis. "The absence of the 'less resistant' minerals in sediments should be attributed largely to solution and alteration either in the source rocks or after deposition rather than to destruction during transport."

The following is a list of sixty-eight minerals, with comments, found in various sands. There is no hard and fast boundary in the discussions of the minerals in this list between sand and gravel.

Actinolite is uncommon in desert sands studied by White. (52, p. 745) According to Condit (8, p. 154) the amphiboles are more common in Ohio glacial sands than in older sands and sandstones.

Albite. Where a sand is the result of deposition after rapid disintegration of granular, acid, igneous rocks, it frequently contains abundant, only slightly weathered, acid feldspars such as orthoclase, microcline, and albite. Such a sand or resulting sandstone is called arkose. Essential conditions, it is generally believed, are: (a) granitic terrane, (b) rapid disintegration and (c) quick deposition. As noted above, Russell discounts entirely the significance of any ordinary concept of quick deposition. (41, p. 1347) Twenhofel states (47, p. 229) that rapid disintegration is favored by aridity, high altitude, or high latitude. White, on the other hand, (52, p. 747) concludes: "It may be of interest to note that none of the (desert) sands studied was appreciably arkosic, a fact that would seem at complete odds with any conjectural notion of the mineralogy of sands of desert origin." Barton (2, p. 439), in his very complete study of arkose, states that it may be formed under less rigorous conditions—usually in deposits of smaller size, in which the feldspar is less fresh, showing the beginning of the decomposition process. The common argillaceous odor of arkose may be due to such predepositional decomposition or to decomposition after deposition as arkose. (E.R.S.) Albite (var. moonstone) has been found in the bed of Williams Creek, Indianapolis, Ind. (49)

Allanite is reported by Russell to be fairly common in all samples from Cairo to the Gulf, although always less than 1% of the heavy minerals. He considers that the infrequency of mention of allanite in detrital sediments is due to lack of recognition rather than to its absence. (41, p. 1328)

Anatase. In one sample of desert sand.

Andalusite. Of 33 desert sands studied by White, (52, p. 745) four showed andalusite.

Apatite. About one-third of the desert sands studied by White (52, p. 745) showed apatite in greater or less abundance.

Augite. The pyroxenes and other ferro-magnesian silicates are uncommon in sands or sandstones unless they are the result of quick deposition of rapidly disintegrated, granular, basic igneous rocks. When cemented, such a rock is called graywacke. (47, p. 175) Because of the ease of decomposition of most of the basic minerals, graywacke is not as common as arkose.

Barite. White reports barite as rare in three of the 33 desert sands studied. (52, p. 745)

Biotite. Uncommon in desert sands. (52) Bleached and battered flakes are found in the Mansfield sandstone of Indiana. (12, p. 131)

Brookite is reported by Gault (12, pp. 131, 132, 133) as a persistent heavy mineral in the Mansfield sandstone. He concluded that it had developed *in situ* because of the perfection of the crystals and because they are sometimes found projecting from fragile specimens of leucoxene.

Calcite is probably the commonest mineral cementing sand grains into sandstone. It is also common (below the zone of weathering, E. R. S.) as comminuted fragments in glacial sand. (8) Many cases of marine sands of nearly pure $CaCO_3$ are reported. Such fragmental, calcareous sands are deposited in the "sand zone" especially off shores of a land of low relief. After deposition, the sand may be picked up by the wind and redeposited in calcareous dunes. There are such dunes on Bermuda composed of coral, mollusk and foram shells or fragments. In addition to the marine calcareous sands deposited off low-lying land areas, fragmental calcareous sands are deposited off shores composed predominantly of limestones. Cases of this type are found on the beaches of Anticosti Island and Gotland where over 90% of the sand grains are of limestone. Calcareous sands, of whatever origin, are characterized by the common features of other sands such as ripple marks and cross-bedding. (47, p. 250) It is probably true that some of the cross-bedding in the St. Genevieve limestone of Indiana, such as may be seen in the old quarries on the penal farm at Putnamville, is of sand-dune origin, although some as evidenced by the coarseness is of beach origin. (E. R. S.) White, (52, p. 744) as a result of his study of desert sand, states: "Calcite is, to be sure, not uncommon in sediments of subaqueous deposition, but in those of desert origin it is ubiquitous."

Cassiterite is the chief mineral of tin placer deposits.

Ceylonite was found in one sample of desert sand. (52, p. 745)

Chlorastrolite (49) found by Dr. Kelso while panning for gold in Brown County, Indiana, is believed to give very positive evidence of the direction of movement of the Illinois glacier—Isle Royale in Lake Superior to Brown County, Ind. Native copper and native silver found in the "gold counties" of Indiana give similar evidence, Keweenaw Peninsula origin. (49)

Chlorite, glauconite, greenalite, serpentine, and epidote are chiefly responsible for the green color of sandstone. Chlorite was found by White in three desert sands. It is a sporadic mineral in the Mansfield sandstone. (12, p. 132)

Chromite. One of the heavy minerals reported in sands and sandstones.

Clinozoisite was reported by White as rare in three desert sands.

Collophane is not commonly reported in clastic sediments. Martens (27) has pointed out the frequency of its occurrence. Russell (41, p. 1331) suggested that, since nearly all samples of lower Mississippi sediments showed collophane, its infrequency of mention may be due to its solubility in acids with which sediments are frequently treated before study.

Corundum. Wade (49) reports, not only chatoyant crystals of common corundum, but also ruby and sapphire of fine quality from the Indiana "gold counties."

Diallage is reported by Russell as being fairly common, but less than 1% of the heavy minerals, in Mississippi River sediments.

Diamond. Occasionally, when panning for gold, there are picked up here and there in the "gold counties," not only in Indiana, but also Ohio, Michigan, Illinois and Wisconsin, diamonds of excellent water up to more than five carats in size. There are records of at least eleven diamonds from Indiana alone. Hobbs has reported a 17ct. and a 23ct. diamond from Wisconsin. (49) These were brought down by the Pleistocene glacier from some as yet undiscovered diamond lodes in Canada. These are but a sample of the tremendous diamond production from placer deposits—streams, the ocean, winds —in South Africa, Belgian Congo, Gold Coast, Sierra Leone, British Guiana, Brazil, Borneo, and India. (17, p. 323)

"In 1835 the great British scientist, Sir David Brewster, stated that, 'Were the diamond not as a gem the head of the mineral kingdom, it would have attained the same distinction from its great utility in the arts.' World War II has certainly proved the truth of this statement. There is no important war weapon that does not employ the diamond in its manufacture." (28, p. 1567)

Diopside. In five of the 33 desert sands studied by White, diopside was reported.

Dolomite is a fairly common cement in sandstones. It is reported by Russell as a common constituent of Mississippi River sediments.

Enstatite is reported by White from five desert sands.

Epidote. Frequent but not always abundant in desert sands. (52) In the Mississippi River sediments up to 10% of the heavy minerals. (41, p. 1328)

Fluorite. Rare in two desert sands studied by White. (52)

Garnet is the coloring mineral in red sands which are common on the Great Lakes and the oceans. Condit (8) reports its common occurrence in glacial sands of Ohio and in the Triassic sandstones of Connecticut and New Jersey. He also suggests that the rarity of garnet in certain pre-Triassic sandstones, such as those of Ohio, is evidence of non-metamorphic sources. Gault (12, p. 132) reports garnets of several colors in the Mansfield sandstone. White found garnet "frequent, but not omnipresent" in the 33 desert sands studied. (52, p. 745) Russell reports three varieties of garnet, one at times up to 17% of the heavy minerals, in the Mississippi River sediments studied.

Glauconite (green sand) occurs in rocks of nearly all ages. Because of its appreciable per cent of potassium, glauconite is frequently used as a locally obtained fertilizer. Its origin has aroused the interest of some of the best mineralogists, but as yet there is no unanimity of opinion. Two schools of thought may be briefly summarized: (a) the glauconite is formed in the presence of organic matter from ferrous sulphide, clay, a potassium compound and water; (b) the glauconite is the result of the progressive decomposition of biotite under marine conditions. (48, p. 402) Glauconite is reported by Russell as never common in the Mississippi River sediments, although it is not an uncommon mineral in the rocks of the upper Mississippi valley (E.R.S.) and in the Tertiary sediments through which the Mississippi flows. (41, p. 1327)

Glaucophane is reported from one desert sand by White.

Gold. Native gold is the ore mineral of placer gold deposits, be they marine sands, present stream deposits or deposits from the geologic past. Placer gold was the gold of the '49 gold rush and the Klondike. It is still the mecca of the lone prospector. For a number of years, however, somewhat less than ⅓ of the U. S. production has been placer gold. (28) A good prospector can see an unbelievably small speck of gold or "color", as he calls it, in his pan. Lindgren (25, p. 253) states that a particle of gold worth 1/2000 cent at the old price ($20 per oz.) can be spotted. Even so, more specimens of "fool's gold" than of real gold are sent in to state geologists for identification. However, once in a while, even in Indiana, real gold is found. Especially in Morgan and Brown Counties, the "gold counties",

a good many thousands of dollars worth of gold have been recovered by farmers in "off seasons", by men out of work or by the butcher, the baker, the candle-stick maker, with gold-panning as a hobby. This gold, like the chlorastrolite, the copper, the diamonds and the silver, was brought down from the north by the great Pleistocene ice sheets. A state inspector of concrete aggregate saw his chance when sand and gravel were being washed from Big Walnut Creek in Putnam County, Indiana, for the new U. S. No. 40 four-lane highway. Twice a day, he would put a strip of Brussels carpet, 27 inches by 48 inches, in the washing flume. When the washer was stopped at noon and in the afternoon, he would take out the strip of carpet, dry it by the fire, and beat it out over a piece of brown paper. Together with much quartz and magnetite sand, at the end of five weeks, he had over $250 worth of gold. In my desk, also, are three grains of gold washed out by David Taylor, a Putnamville H. S. boy, from Mosquito Creek just south of Putnamville, Ind.

Gypsum. The widely known white sand dunes of Otero County, New Mexico, appearing from a distance like white-caps on an inland sea, are largely composed of nearly pure granular gypsum. It had been eroded from "ribs" of Permian gypsum rising at intervals above the saline flats. (16) Gypsum is also a common constituent of the salts deposited in desert playas.

Halite. Thoulet (45) has reported minute amounts of halite in desert sands outside of playas, but in playas it is so abundant as to have been the basis of the Grabau-Walther theory of the origin of great salt deposits.

Hematite. Condit (8, p. 159) reports that hematite is found as inclusions in quartz and as a cement in red sandstone. White (52, p. 745) noted hematite as a common constituent of desert sand. Surprisingly, Russell (41, p. 1328) reports hematite as more common than limonite in the sediments of the lower Mississippi.

Hornblende. Condit (8, p. 158) reports the hornblende in Ohio sandstone as being much weathered. Sandstones with considerable hornblende would be considered as graywacke. Gault reports hornblende as a sporadic mineral in the Mansfield sandstone of Indiana. (12, p. 133) Russell (41, pp. 1319, 21, 23, 25) found hornblende up to 15% of the heavy minerals. According to White, half of the 33 desert sands studied showed hornblende and it was abundant in two samples. (52, p. 745)

Hypersthene was found in glacial sands by Condit; common in a few desert sands by White; fairly common (up to 3% of the heavy minerals) by Russell.

Ilmenite, whose local abundance in beach sands of Florida has given those sands economic importance, is one of the heavy minerals. To its black color, not that of magnetite, is due the name "black sands" of the heavy-mineral sands of Florida. These heavy minerals have been carried by streams and shore currents from the states between Virginia and Georgia down to Florida. Since the heavier minerals tend to be dropped first, unless they are markedly finer grained than the average, the sparsity of such minerals as ilmenite in the beach sands from Virginia to Georgia poses, in the opinion of the writer, a very real geomorphological problem. Is it not very probable that in the Pleistocene the drainage from the source states was directly to Florida instead of into the Atlantic farther north? Further evidence of the reasonableness of such a suggestion is the distribution of the heavy minerals on both sides of the Florida peninsula. In the Mansfield sandstone of Indiana, Gault reports ilmenite as making up 5-20% of the heavy minerals. (12, p. 133) In the Florida deposits 43%. (34) It is frequently abundant in desert sands. (52, p. 745) Mississippi River sediments contain high, although variable, percents (6-50% of the heavy minerals) of ilmenite. (41, p. 1328)

Iolite was reported from the dune sand of Holland. (36)

Iridosmine. This natural alloy of iridium and osmium is derived chiefly from placer deposits.

Kaolinite. Various clay minerals are reported disseminated and in "clay balls" in sands and sandstones.

Kyanite. About one-third of the desert sands studied by White contained kyanite. (52, p. 745) Russell reported kyanite as rare up to 1% of the heavy minerals in the lower Mississippi sediments.

Leucoxene is a heavy mineral, decomposition product of ilmenite and found associated with that mineral in the Mansfield sandstone of Indiana, 40-70% of the heavy minerals; (12) not common in desert sands; (52) 1-7% of the heavy minerals in the lower Mississippi sediments; (41) and astonishingly not listed from Florida by Phelps. (34)

Limonite is regarded by Condit as equally omnipresent with quartz, although usually not over 3-4%. It is the cement in brown sandstones, such as the famous stone of the "brown-stone-fronts", so widely built along our eastern seaboard at the end of the last century.

Magnetite is the common mineral of black sands (not Florida) and can be separated out with a magnet. It is generally not of economic importance because of its low tenor and also its high percent of titanium due to associated ilmenite. In gold panning, the gold is usually found with a magnetite residue in the bottom of the pan. One dune sand from California contained 15% magnetite. (38, p. 385) For economic reasons, the Japanese are said to have concentrated and utilized marine sands as iron ore. White reports that magnetite was not common in desert sands studied. It is but a sporadic mineral in the Mansfield sandstone of Indiana. (12) Russell reports that the percent of magnetite in the heavy minerals in the Mississippi sediments varies between 0.9 and 42%. (41, p. 1318 et seq.)

Marcasite is not commonly reported in sands and may be mistaken for pyrite.

Microcline. Discussions of albite and orthoclase apply to microcline, although it is reported by H. R. Wanless as the most resistant of the feldspars.

Monazite sand is the chief commercial source of the "rare earths"—thorium, cerium, lanthanum, praseodymium and neodymium. With the decline in the use of thorium for Welsbach mantles, other uses for thorium and the other rare earths have been sought. Resulting uses include glass, ceramics, alloys, printing and dyeing, and moth- and rot-proofing of textiles. (28, p. 767)

Muscovite is a common mineral, although not in large amounts, in sands and sandstones. Both rust-stained muscovite and bleached biotite have been mistaken for gold. In the Mansfield sandstone of Indiana, muscovite forms 1-10% of the heavy minerals. (12, p. 132) Muscovite is one of the uncommon minerals in the lower Mississippi sediments.

Nephelite.

Olivine was found in one desert sand by White and rare to fairly common in the lower Mississippi sediments by Russell.

Orthoclase is reported in the sands of Ohio as usually more altered than albite. (8, p. 158) Russell reports (41, p. 1326) orthoclase up to 3% of the total minerals on the 100-mesh sieve. He shows surprise at the amount of fresh feldspar in these lower Mississippi sediments.

Platinum. In peace times, only a small part of the world production of platinum comes from placer deposits. Such sources, however, can be so rapidly increased in time of war that they provide much greater amounts during the war years. The absence of platinum from the Canadian "shield" is indicated by its absence from the glacial deposits in the "gold counties" of Indiana, etc.

Pyrite. White reports pyrite in one of 33 desert sands studied. Gault reports it as sporadic in the Mansfield sandstone of Indiana. Russell found pyrite from rare to 45% of the heavy minerals in the Mississippi river sediments. (41, p. 1318 et seq.)

Quartz. Although, as pointed out, to be sand, a sand does not have to be even over half quartz, it is the chief constituent of practically all sands. It is so frequently over 95% as to suggest the correctness of the general impression that sand is quartz.

Rutile was found in about one-third of the desert sands studied by White. (52, p. 745) It is not common in the lower Mississippi sediments. Gault reports that rutile is 1-10% of the heavy minerals in the Mansfield sandstone. (12, p. 133) Phelps reports it as the third commonest (10-26%) of the heavy minerals in the Florida deposits. (34, p. 168)

Serpentine.

Sillimanite. Of 33 desert sands studied by White, five showed sillimanite, one in abundance. (52) Sillimanite was reported as rare to less than 1% of the heavy minerals in the samples studied from the lower Mississippi. (41, p. 1330)

Silver. Wade reports that one of his students found a specimen of native silver in the gravels of Fall Creek, Indianapolis. On analysis, the resemblance to Keweenaw-Peninsula silver was striking—another evidence of direction of ice movement. (49) Silver is frequently found in placer deposits, but in much smaller amounts than gold.

Spinel.

Spodumene was reported in two desert sand samples studied by White. (52)

Staurolite is found in sands derived from metamorphic regions. It is reported by White to be frequent, but not omnipresent, in desert sands; (52, p. 745) and by Phelps sporadic in Florida sands. (34)

Sylvite occurs in minute quantities in some desert sands and in larger amounts in playa deposits.

Titanite is uncommon in desert sands (52) and up to 3% in lower Mississippi sediments. (41, p. 1318 et seq.)

Topaz was reported by White in two desert sands, none in the lower Mississippi sediments studied by Russell.

Tourmaline is reported by Phelps as a minor constituent of Florida heavy sands; by Gault in the Mansfield sandstones, as 5-20% of the heavy minerals; by White as widely distributed in amounts less than 1% in desert sands; by Russell as widely distributed in amounts less than 2% in the lower Mississippi sediments.

Vesuvianite is reported in two desert sands studied by White.

Xenotime.

Zircon was reported in desert sands by White; as second commonest (13-26%) heavy mineral in the Florida deposits by Phelps; (34) 20-50% of the heavy minerals in the Mansfield sandstone by Gault; (12, p. 133) by Russell (41, p. 1330) up to 9% of the heavy minerals in the lower Mississippi sediments; by Wade (49) as colorless to violet crystals in Indiana glacial sands.

Zoisite was reported by White as rather common in small quantities in desert sands; (52) and by Russell in small amounts in all samples of Mississippi sediments. (41)

The preceding list is certainly not complete, yet it is believed to contain most of the minerals which have been reported from sands.

Shape of Sand Grains

The most complete study of sand grains ever carried out was by Ries and Conant of Cornell Univ. (38) Certain of their conclusions follow:

Sands produced by weathering of igneous or metamorphic rocks would probably be angular and rough; glacial, stream and beach sands

may also be angular because of brevity of the grinding processes. Volcanic sands would usually show volcanic glass or pumice and have an angular or splintery form. Transportation may cause rounding of the grains either by corrasion or, as pointed out by Galloway, if in water, by solution. (10) In water, the contact grinding is counteracted to some extent by the film of water surrounding the grains, which acts as a cushion—the cushioning effect being greater, the smaller the grains. Galloway notes that rounding due to solution will be more important, the finer the grain. (10)

In wind-blown sands the rounding due to corrasion may affect smaller grains than in the case of water-borne sands. Although Galloway (11) states that, if over 50 per cent of the grains are well rounded, the sand is wind-blown, Ries and Conant report many wind-deposited sands with comparatively few well rounded grains. Rounding of hard grains is evidently a very slow process for few marine or river sands show a large percentage of rounded grains. Of 58 river sands, only 22 showed rounded grains and abundant in only a few. Of 59 marine sands, only 19 showed rounded grains. Even in these cases some of the rounded grains may show characteristics inherited from a previous wind-blown environment. (38) The sand from West (sic) Palm Beach mentioned above was described by Shaler (43) as having mostly subangular grains, though the material has been transported for many miles along shore from the Piedmont region to the north.

E. M. Kindle has pointed out that sand grains are rounded by passage through the bodies of marine animals such as sea urchins. (23, p. 431)

The question arises, "How round is a sand grain?" Trowbridge and Mortimore (46, p. 405) used the terms: "well rounded," "fairly well rounded," "sub-angular," "angular," but the use of such descriptive terms will vary with the individual. Wentworth suggested methods of study and classification which could be used on pebbles and larger rocks. (51) E. P. Cox (9, p. 180) suggests a definition of roundness, the circularity of a two-dimensioned figure, which may be measured in a decimal fraction in the following manner:

$$\frac{\text{Area}}{(\text{perimeter})^2} = \text{constant},$$

which is $\frac{1}{4\pi}$ for a circle. Therefore, the above equation multiplied by 4π gives

$$\frac{\text{Area} \times 4\pi}{(\text{perimeter})^2} = \text{K}.$$

K is a constant that is dependent upon the shape of the figure, being 1 for a circle and less than 1 for any other shape, but it is the same for all figures of the same shape regardless of size. K for a figure of any given size represents the percentage ratio that the area of the figure holds to the area of a circle with the same perimeter. The constant for a square is 0.785, for a given right isosceles triangle, 0.54—the percentage roundness of those two figures.

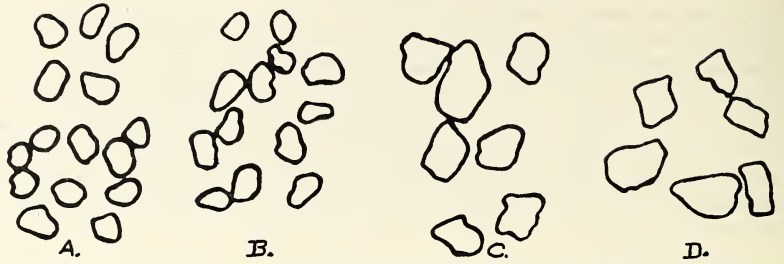

Fig. 4. Tracings of photographs of sand grains diagnosed by Trowbridge and Mortimore as (A) "rounded," (B) "fairly well rounded," (C) "subangular," and (D) "angular." A mathematical study of these tracings according to the Cox method (9, p. 181) indicates an average sphericity of A—0.902; B—0.85; C—0.88; D—0.76. This would indicate that grains called "subangular" by Trowbridge and Mortimore are more rounded than those called "fairly well rounded."

Several methods for measuring these values for a set of grains are suggested by Cox. Where thin sections or photographs have been made, project the image on a screen. Loose grains may be sprinkled on a lantern slide previously covered with a thin layer of mucilage and the image projected on a screen. The area may be measured by a planimeter and the perimeter by a map-cyclometer. The suggestion is made to substitute the map-cyclometer for the pointer of the planimeter, the results set on slide rule and the ratio read off directly as the figure denoting "roundness."

It is suggested that the above equation overlooks the factor of roughness which, unless "smoothed out," would markedly increase the denominator. Of course, where a particle has been transported far by either wind or water, a surface originally rough due to differential chemical or physical weathering would be somewhat smoothed in the rounding process.

Sherzer (44, p. 634) quotes a table from Mackie (26) indicating, possibly too "roughly," the "roundability" (*psephicity*) of the common sedimentary minerals in water and in air.

Table IV. Relative *Psephicity* of Sedimentary Minerals in Water and Air (Sherzer after Mackie)

Quartz	.23	.38	Orthoclase	.29	.40
Labradorite	.29	.45	Hornblende	.39	.57
Biotite	.70	1.05	Muscovite	.86	1.30
Magnetite	.70	.86	Garnet	.39	.53
Tourmaline	.30	.43	Zircon	.45	.59
Rutile	.51	.68			

In addition to roundness, sand grains which have been transported and eroded by wind frequently assume the appearance of ground glass. Where grains with this type of surface are found in water-laid sediments, as in the Pleistocene marls of Florida, it is concluded that they show evidence of an earlier airborne cycle.

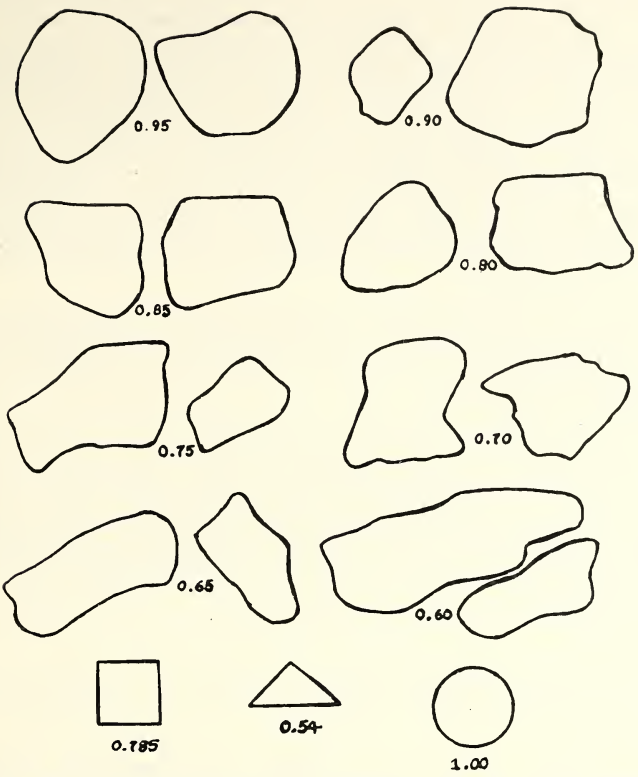

Fig. 5. Mathematical Statement of Sphericity of Two Grains Each of Several Degrees of Roundness with Three Simple Geometrical Forms for Comparison. (9)

The Classification of Sands Based on Origin

A number of classifications of sands based on origin have been made, notably by Sherzer (44) and Grabau. (13, p. 288) The classification by Grabau is the more complete. With the more technical terms omitted, it is given in Table V.

Table V. Classification of Sands Based on Origin (mod. after Grabau)

A. Clastic Sands

1 Glacial	2 Volcanic
3 Residual	4 Aqueous
5 Eolian	6 Artificial[3]

B. Non-clastic Sands

7 Organic	8 Concentration (Precipitation, E.R.S.)
9 Snow and firn (névé)[3]	10 Igneous[3]

A brief, but fairly complete, discussion of types 1-5 and 7-8 is given by Sherzer. (44, pp. 628-650)

[3] Added to Sherzer Classification by Grabau. (13, p. 288)

The Production and Uses of Sand

Although, as discussed above, the word sand as a natural product covers merely a given size of grain, under the production and uses of sand a more or less pure quartz sand is implied. In order of amount of production in 1943, the chief uses of sand are listed in Table VI. The value per ton usually indicates the purity (mineralogical or bachteriological) required for a particular use. In the United States, in 1943, some 31,000 men were employed in the production of sand and gravel. This does not, of course, include the large numbers employed in the industries dependent on the sand and gravel.

Usually for *building* and *paving* purposes a sand should be "sharp," (with angular grains) and free of clay and organic materials. Otherwise, a reasonable per cent of quartz, possibly 70 per cent, is the minimum requirement.

Foundry sands (37, p. 749) are the siliceous and other sands used in making forms for casting metals. To the foundryman a "sharp" sand is one that is free of a bond. Naturally bonded sands contain a variable (3-25 per cent) amount of clay. Synthetic foundry sands are mixtures of "sharp" sand with required amounts of clay or bentonite as a bonding material. If used in the cores, the bond may be oil, cereal, resin, pitch, etc.

Table VI. Sand Production in the United States in 1943 (28, p. 1324)

	Production (1)	Price Per Ton	Total Value (2)
Building	30,911	$ .60	$18,662
Paving	23,440	.61	14,305
Foundry	8,925	1.36	12,094
Glass	3,972	1.86	7,377
Engine	2,862	.69	1,983
R. R. Ballast	1,320	.31	412
Abrasive	838	1.71	1,428
Furnace	395	1.37	539
Filter	159	1.63	259

(1) Production in thousands of short tons.

(2) Total value in thousands of dollars.

The important properties are fineness and bonding strength. A foundry sand may contain particles ranging from 3 mm. (granule in the Wentworth classification, Table II) down to clay. The grains may be smooth or rough, clean or stained. Some foundry sands contain compound grains, which have been suggested as possible causes of small explosions in casting. (38, p. 392)

Bonding strength is determined by the amount of clay, the amount of water and the angularity and roughness of the grains.

Sintering Point, the point of incipient fusion, is not now considered by foundrymen to have much importance. *Durability*, life or number of times a molding sand may be used, is much less important than formerly because of the much increased use of the so-called synthetic sands. In fact, some foundries now are even using granite pulverized to the desired fineness with added binder. Foundrymen are also questioning the importance of *permeability* because the gases pass away from the mold face through vents and because it has become common practice to coat the mold face with a clay wash.

In recent years the practice has been introduced of using a sand with a high content of zircon either: (a) throughout, or (b) at points where quick chilling of the cast is important, or (c) as a wash on the mold face. The reasons for this are: (a) the low thermal expansion of zircon as compared with quartz; (b) its high thermal conductivity; and (c) its high melting point (3650° C.—3850°C.).

Glass Sand. (37, p. 754) The requirements for glass sand are a fineness of 100-20 mesh and chemical composition determined by the use to which the glass will be put. Tab. VII gives chemical specifications for four typical uses of glass sand.

Table VII. Specifications for Chemical Composition of Glass Sands (Ries after Weigel)

Quality	SiO_2 Min.	Al_2O_3 Max.	Fe_2O_3 Max.	CaO, MgO Max.
First quality, optical glass	99.8	0.1	0.02	0.1
Fourth quality, plate glass	98.5	0.5	0.06	0.5
Sixth quality, green glass containers and window glass	98.0	0.5	0.3	0.5
Eighth quality, amber glass containers	98.0	0.5	1.0	0.5

Filter Sand. (37, p. 757) Sand is used by communities and large industrial users of water to remove sediment and bacteria. The essentials are: (a) fineness 35-14 mesh; (b) uniformity of size; (c) of such a composition as not to be decomposed or disintegrated by water (high in quartz); (d) shape not flattened or elongated; (e) freedom from organic and bacterial impurities.

A decrease in production of filter sand beginning in 1930 is probably due to: (a) cleaning and re-use of sand; (b) considerable use of granular anthracite coal; and (c) use of a thinner sand bed with gravel beneath.

Abrasive Sand, (37, p. 759) with a wide variety of uses such as stone-sawing, glass-grinding, quartz, garnet and emery papers, and sand-blasting, tends to be replaced by artifical abrasives such as carborundum. For some uses ground-up garnet and emery are preferred.

Where large deposits of garnet sand are available, as at a few localities in Florida, it would seem to the writer that they could be used to good advantage, especially in garnet paper. Size of grain and hardness are the chief prerequisites for use of sand as an abrasive.

Engine Sand (37, p. 761) is used to prevent the driving wheels of locomotives from slipping. The chief requirements are a sand high in silica and of size roughly 80-20 mesh.

Furnace Sand resembles fine-grained molding sand and is used to line open-hearth steel furnaces. It may run as low as 80 per cent quartz and, if lacking in a clay bond, plastic fire-clay is added.

Oil- and Gas-Sand

One of the prime prerequisites for the economic concentration of oil and gas is a reservoir rock. This is usually called oil- or gas-"sand," although it may be limestone, dolomitic limestone, fractured shale, fault breccia, or porous or fractured igneous rock, as well as sand or sandstone. Until about 1932, it was almost universally believed among oil men and even yet it is frequently stated that the factor which makes the "oil-sand" a reservoir is its porosity. Actually, as pointed out by Nevin, (29, p. 374) "permeability and not porosity is the controlling factor." "Aside from the fact that a substance must be porous to be permeable, porosity and permeability have no relation. A sand with low porosity may have relatively high permeability, and the high porosity of many shales (30-40 per cent) is coupled with a very low permeability. The porosity of an oil sand is the ratio of the pore space to the volume of the sand."

The Handbook of Foundry Sand Testing, 5th Edition, (p. 26) defines permeability and discusses the determination of the "permeability number" specifically as it applies to foundry sands, but actually as it applies to the study of permeability of a rock wherever such information is desirable.

Permeability is the physical property that permits the passage of gases or fluids. Sands and sandstones are tested for the permeability number with an air-flow apparatus. The permeability number is the volume of air in cc. that will pass per minute under a pressure of one gram per sq. cm. through a specimen one cc. in volume.

$$P=\frac{v \times h}{p \times a \times t}, \text{ when}$$

P=permeability number
v=volume of air in cc.
h=height of specimen in cm.
p=air pressure in cms. per sq. cm.
a=cross-sectional area of specimen in sq. cm.
t=time in minutes.

Standard testing methods require 2,000 cc. of air to be forced through a specimen 5.08 cm. in height and 20.268 sq. cm. in area.

The fallacy (29, p. 374) of considering porosity and permeability as synonymous, or as being interrelated, or of using porosity as a short cut to permeability is indicated by examination of the following data from three tests of the Bradford, Penn., sand by Nutting (31, p. 44) as given by Nevin:

Table VIII. Relation Between Permeability Number and Porosity

Permeability Number	Porosity
A 7.9	15.3%
B 1.1	15.9%
C 1.2	19.4%

Specimen A, with a permeability number of 7.9, has a porosity of 15.3 per cent, while specimen B, with a permeability number of but 1.1, has almost the same porosity as A—15.9 per cent. On the other hand, specimen C, with nearly the same permeability number as B has a porosity about one-fourth greater.

The permeability of an "oil-sand" determines: (a) the correct spacing of wells for complete economical production; (b) the possibility of economical repressuring of an "oil-" or "gas-sand" by delay of drilling the central well in "five-spot" repressuring, if there are permeable streaks in the midst of "tight" reservoirs; etc.

Nevin concludes that, although a thin layer of oil or water is adsorbed by the sand grains, permeability to air gives reliable results, as a similar layer of air is adsorbed by the sand.

Quicksand

From a human point of view, one of the most interesting and important phases of sand is quicksand. Such interest is evinced in its repeated use by the novelist in the development of a plot—"Toilers of the Sea," "Moonstone," "The Bride of Lammermoor," "Assignment to Brittany," "The Hound of the Baskervilles," and "Lorna Doone." It is also the central theme in cartoons such as that in a recent "New Yorker," in which a very English explorer up to his arm-pits in quicksand, looking at his wrist watch, remarks to his compatriot, "Not so *very* quick, it it?"

The economic importance is indicated by the large number of horses, cattle and sheep which are lost each year in quicksand deposits. In one body of quicksand, to which my attention was recently called, three cattle had been engulfed in the last few years. To protect the rest of his herd, the owner spent considerable time drawing logs and brush into this area possibly 150 feet across. (24) It is reported that, through the years, many ships have been swallowed up after running aground on quicksands. In 1875, a train was engulfed after running off a bridge near Pueblo, Colo., and was never recovered, although the quicksand was probed to a depth of 50 feet.

What makes quicksands quick? A remarkable phase of the answer to this question is that the geologist has lain down so comfortably alongside his ignorance of the solution of a problem, at once so full of human interest and economically so important. Evidence of the truth, that the geologist has not solved the problem, is that a careful search of bibliographies of American geological literature, 1785-1941, revealed but one rather brief paper in a rather unimportant geological publication. (6) This paper, on further investigation, presented the theory which seems nearest the truth, but was based almost entirely and without proper credit on a rather obscure set of remarks on four words in a paper on the cost of excavating one level in the Erie Canal.

Before presentation of this theory, a list of other theories with brief discussion will serve to clarify the problem.

Rounded grains. The writer, in common with many others, started out with the theory that quicksand was simply a sand almost entirely composed of spheroidal grains, which, when lubricated with water, would roll out from under the submerging body, permitting it, especially if it struggled, to be engulfed. A number of considerations make this position untenable, the chief of which is the study of sand grains by Ries and Conant (38) which pointed out, after the study and photographing of literally hundreds of specimens of sands and sandstones, that practically never does a sand or sandstone exist with over 50 per cent rounded grains and that, where any considerable per cent of the grains are rounded, it is evidence of the desert origin of the sand. Another question arises—in the case of large bodies, what would become of the sand that rolled out of the way of the body?

Loose-pack-close-pack. A possible answer to this second question was proposed by Bancroft. (1) In places where, due to up-welling currents of water, the sand grains were "loose-packed," that is, grains of roughly equal size were arranged in straight horizontal and straight vertical rows, there would be a maximum of pore-space, approximately 38 per cent. A struggling body would tend to jar these grains into a close-packed arrangement, in which alternate layers would fit down into the hollows between the grains in the layer below, leaving a pore-space of approximately 26 per cent. The difference of 12 per cent would permit entrance of the struggling body. This theory has been accepted by others. Bancroft's failure, however, to find any supporting evidence caused him to abandon the search of what makes quicksand quick.

Other theories have been: a coating of clay on the sand grains to increase the mobility; a similar coating of decaying organic matter; and the presence of mica grains.

In 1927, in the Pan-American Geologist, (6) Burt discussed the origin of quickness in sands, following very closely a discussion by Hazen (15) in 1900. The Hazen discussion dealt with four words, "Quicksand (rounded sand grains)." Hazen picked up those four words from a previous engineering publication and in five pages laid the basis, not only for Burt's paper, but also for present engineering theory on the question.

In brief, the Hazen theory is that quicksand is found where there is a spring with sufficient upward water movement to *lift the sand grains apart*, so that the practical result is that a body goes down into water, somewhat handicapped by sand, rather than into sand lubricated by water. Quicksand is not a material, nor even a type of deposit, but rather a condition of equilibrium, or lack of equilibrium, between the materials of the deposit and the ground-water. Tab. IX is excerpted from the table of velocities of upward moving water necessary for the lifting of quartz grains of given diameter:

Table IX. Velocity of Water Necessary to Lift Quartz Grains Apart

Vel. of Water in ft. per hr.	Diameter of Quartz Grains in mm.
1.5	0.03
4.	0.05
16.	0.10
65.	0.20
148.	0.30
262.	0.40
410.	0.50

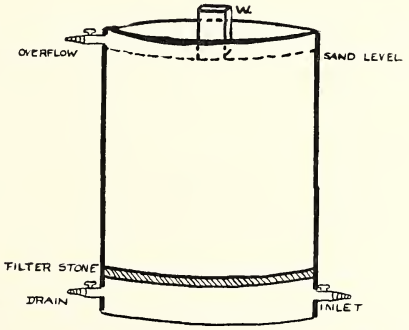

Fig. 6. H. T. Jenkins Apparatus to Illustrate "What Makes Quicksand Quick."

Figure 6 is a sketch of a device by H. T. Jenkins of Cornell University to illustrate the Hazen theory of the cause of quicksand. With dry sand the weight (w) remains in place, no matter how much effort is exerted to bury it in the sand. Even when water is admitted through the bottom inlet valve and the sand is entirely wet, still the weight cannot be buried in the sand. The fact that sand makes a good foundation for a great dam was utilized in the dam over the Mississippi River near Alton, Illinois, where the dam, footings and all, were placed in and on sand. (39) However, when the water is admitted at a rate sufficient to lift the grains apart, the weight buries itself in the sand almost as if it were a person diving into a swimming pool. Then, if the water is shut off and the weight is extricated and again placed on

the sand, the sand is again stable and the weight does not sink in. Sand which had formerly been quick is so no longer, although it feels slightly quick to the fingers.

Table IX also indicates why quicksand is invariably fine grained. Velocities of spring are seldom sufficient to lift any but fine sand grains apart.

A number of questions regarding this Hazen theory arise:

If springs are always associated with quicksand, that fact should be indicated in the summer months by the temperature of the water as compared with the ordinary stream water. Last spring, under the guidance of Mr. J. T. Christie, I located a quicksand deposit on the Heber Ellis farm in Long Branch some four miles west of Greenscastle, Indiana. This quicksand was on both sides of a fence crossing the stream, so that it could be relocated absolutely accurately at a later date. In August, I returned to the place. There was no quicksand; it was gravel; there had been a number of very heavy rains this summer. However, the temperature of the water in the gravel (formerly quicksand) was 3°F. cooler than anywhere else tested in a half-mile of the stream—indicating, it seemed to me, a spring, even though there was no quicksand there in August.

Another question arises: If a spring is necessary for quicksand, how can it be possible that pockets of quicksand vary in position from time to time? The truth of this movement is attested to by several fishermen of my acquaintance. An hypothetical answer is suggested: In two miles of a stream, there are five springs—a, b, c, d, and e. At b and d the sediments are sufficiently fine on May 1 to be quicksand; at a, c and e, there is gravel. Late in May, there is a flood, as a result of which gravel is deposited on all springs but e; so there is no quicksand when the fisherman wades the stream June 1 at either b or d, but there is at e; he decides that the quicksand has moved down from d to e, which it may or may not have done.

Hazen gave as an illustration of sand becoming quick with upward water movement the Western Union Building in New York City. It was constructed with a load of 3¾ tons per sq. ft., safely sustained. Sometime later, wells on adjoining land being pumped began to show cloudiness and the building began to settle. When the pumping was stopped, the building no longer settled.

In addition to the loss of life in quicksand, it also presents a problem which demands the best of the well driller, the builder and the excavation engineer. Prelini (35, p. 188) suggests that the necessary procedure in tunneling quicksand is to drain away the water and prevent the collapse of the sand by strutting the sides with tight boards. In ditching for agricultural tile, a shield may be pushed ahead of the tile to keep the quicksand back. In streams in the cattle-states of the West, where there is abundant quicksand, the cattlemen believe that the quicksand problem can be temporarily solved by driving a herd of cattle rapidly through the quicksand patch, thus packing it down and shutting down the flow of water.

A topic of considerable discussion regarding quicksand is as to whether cattle or men are ever completely engulfed. An article in Science News Letter (42, p. 232) was entitled: "You're safe in quicksand, if you keep still" and presented the following argument: "If you ever have the misfortune to fall into quicksand, don't get panicky and thrash around. If you keep quiet, allow yourself to go down feet first and keep your arms outstretched, you will soon find yourself resting at a depth just below your armpits. . . . You stop sinking when your weight equals that of the quicksand you displace. As a matter of fact, quicksand will support you twice as easily as water." The above suggestion was made by Laurence Pirez, director of the Soil Mechanics Laboratory at Cooper Union, in New York.

Not all soils physicists agree with Pirez. Jenkins contends (19) that the buoyant effects of the quicksand is due only to the water present plus the very slight uplifting by the upward movement of the water.

That the estimate by Pirez was of doubtful validity is indicated by comparison of the two statements—"you will soon find yourself resting at a depth just below your armpits" and "quicksand will support you twice as easily as water." If the latter statement is true, the body would come to rest slightly above the waist instead of just below the armpits.

The advice not to thrash around, thus weakening you, is good, as animals, including man, will drown due to exhaustion, or heart failure may result. As to whether an animal will be engulfed will be determined by the specific gravity of its body.

In the previous discussion, it has been assumed, following Hazen, that the only cause of lifting in quicksand is spring water. Sand grains or any soil particles may be made quick by lifting apart by rising gas. This effect is shown especially in the "cratering" of an oil or gas well out of control. After the crater has been formed by the initial explosion, the gas continues to rise through the soil and changes what had been a sound base for drilling equipment into terrifically quick material which may swallow up hundreds of tons of drilling rig, casing, engine, etc. (14)

Sonorous Sand

Under this name, may be included singing, squeaking and barking sands. I have not tested and see no way to test theories of the cause of these phenomena. Several articles by H. C. Bolton and A. A. Julien toward the end of the last century dealt with theories of causes. (3, 4, 5) Singing sand gives off a sound akin to that of a sawmill; squeaking sand, a rather shrill note; barking sand is described as emitting a hoot-like note as the heel is lifted in walking across the sand, or, if the sand is confined in a bag, when the two ends are folded together. Singing sand is considered by Bolton and Julian to be necessarily dry sand, either siliceous or calcareous, giving off the note on being blown by the wind. Their theory was that all types of sonorousness are due to

thin films of air, as elastic cushions between the grains. These cushions are capable of considerable vibration, thus emitting the sound. Kegel (21) attribues the singing of sand in desert regions to change in position of the constituent grains caused by difference in temperature between day and night. Bolton and Julian state that they have records of over 1,000 localities with singing sand.

Squeaking and barking sands are always moist and lose their sonority on drying. The most famous example of barking sand is on the island of Kauai, Hawaii, (4) but it is reported (33) that much better barking sand is found near Beaufort, N. C. That on Kauai is highly calcareous, the individual grains very angular. (E.R.S.)

Conclusion

Although the path which we have trod is but little of it new, we have built into our route parts from many other trails, and all from whom we have asked help or guidance have been quick to respond. We have not even dodged the quicksands, nor the biological sands, even though full of disease they may be.

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When the Seasons Begin in Indiana

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The conventional beginning dates of the seasons, December 1, March 1, June 1 and September 1, or the "astronomical dates" of the solstices and equinoxes, (December 22, March 21, June 21 and September 22) do not coincide closely with the beginning of the seasons as they are felt in Indiana. The average dates, obtained from the daily temperature normals (average of day and night for many years) are here given for Indiana on several other bases. These dates have real significance and hence considerable interest.

The coldest quarter of the year commences for most of Indiana about December 3. If winter is defined as the season when the temperatures are below freezing, for the average of day and night, it commences in northern Indiana about December 3, in central Indiana about December 15, and in southern Indiana about December 22, except in the Ohio River lowland, where daily normals below 32° are lacking.

If spring is defined as the quarter of the year following the coldest quarter of the year, it commences in southern Indiana about March 1, in central Indiana about March 4 and in northwestern Indiana about March 7.

If spring is defined as the season when the daily normals rise above the freezing point, it commences about February 15 in south central Indiana, about March 1 in north central Indiana, and about March 6 in northern Indiana.

Appreciable plant growth of hardy plants commences when the daily temperature normals rise above 35°. This occurs about mid February near the Ohio River, about March 1 across the southern part of central Indiana, about March 15 in the southern part of northern Indiana.

Mild spring (daily normals rise above 50°) commences about April 5 in southern Indiana, about April 15 in central Indiana and about April 20 in northern Indiana.

The average date of the last killing frost in spring comes somewhat later than the dates just mentioned, when the daily normals rise above 50°. The average frost-free season commences about April 20 in much of southern Indiana, about May 1 in much of central Indiana and near Lake Michigan, but not until about May 7 in considerable areas in the elevated eastern and northeastern parts of the state, and in the northwest away from Lake Michigan.

As corn makes little growth when the temperature is below 55°, the date when the average temperature normals exceeds 55° is of interest in Indiana, because of the local importance of corn. In the southern part of the state "the corn-growing season" commences about April 20, except along the Ohio and lower Wabash river bottoms. In central Indiana it commences about April 25, along the upper Wabash river it

commences about May 1, but in the northern counties not until after May 5.

The warmest quarter of the year commences in most of Indiana nearly a week after June 1. In the northwestern part of the state, however, this warmest quarter does not commence until about June 10.

If summer is defined as the season when the temperatures average 68° or higher, summer commences in the last week in May in the southern fourth of the state, during the first week in June in the central one-fourth of the state and in the second week in June in the northern one-fourth.

Hot summer, that is, averages of day and night together of 75° or higher, commences about June 15 in the southern tier of counties, about July 1 along a line from Cincinnati to Terre Haute, during the first week in July in most of central Indiana and in the second week in July in the northern and eastern part of central Indiana. Daily normals of 75° are lacking in the northernmost counties, despite the fact that they occasionally have very hot days. When however, the temperatures of all the days and nights of 40 years are averaged, the highest total is somewhat below 75°.

The beginning date of autumn depends, therefore, on what criteria are used. Hot summer ends in early August in the part of northern Indiana that attains that level, it ends about August 10 in most of central Indiana, about August 20 in most of southwestern Indiana, but not until about September 1 in the hottest southwestern corner of the state.

The third quarter of the year, so far as temperature is concerned, commences not on September 1 but about September 8 in almost all parts of the state.

If autumn is defined as the season when the daily normal temperatures fall below 68°, it commences for much of northern Indiana about September 5, for much of central Indiana about September 10, for much of southern Indiana about September 20, but not till September 25 along the lower Ohio river bottom.

Cool autumn weather, daily normals below 50°, commences about October 20 in northern Indiana, during the last week of October in most of central Indiana, and during the first week of November in southwestern Indiana.

The season of frequent killing frosts commences about October 10 in most of the northern half of Indiana, and about October 15 in most of southern Indiana.

The average date of the snowfall of measurable amount (not snow flurries) is during the first week of November in northern and northwestern Indiana, about November 10 in most of central Indiana and during the third week of November in extreme southern Indiana. Although the amount of rainfall received in Indiana varies greatly from time to time, the variation is irregular; no particular season normally is especially dry or exceptionally rainy. Hence no discussion of the beginning dates of wet or dry seasons is appropriate here. (For most

of the world such seasons are as real and often much more significant than the seasons based on temperature contrasts.

Further details on the beginning dates of most of the types of seasons here considered, with data on their ending and average lengths, with many maps showing local contrasts within the state, are given in "Climate of Indiana," Indiana University Series 1944, 511 pp. The present summary considers, however, three sorts of seasons not there discussed, and brings together data presented in scattered chapters of that volume.

Summary

If the year is divided into four equal seasons on the basis of normal temperatures, they commence between the common calendar beginning dates and the "astronomical" beginning dates. For each of the seasons, the almost imperceptible break in the temperature curve occurs shortly after the first of the month. Winter commences on December 3, not December 1 or December 22; summer commences on June 7, not on June 1 or on June 21.

When the year is divided into fewer or more than four seasons, their beginning dates correspond only approximately with those just mentioned, and display more regional contrast within Indiana. Temperatures normals below 32° commenced soon after the first of December in northern Indiana but not until about December 22 in southern Indiana. Conversely if spring commences when the temperatures rise above 32°, it begins in early February in southern Indiana but a month later in northern Indiana. Considerable plant growth of hardy plants commences about two weeks later, for most of central Indiana about March 1. Mild spring commences during the first half of April in the southern half of the state, if daily normals of 50° is used as a basis. Most people feel that spring does not really come to Indiana until April. The season normally lacking in killing frosts commences for most of Indiana late in April, but not till May in parts of northern and northeastern Indiana. The season of active growth of corn (daily normals of 55°) commences about the time when killing frosts cease to become normal.

Summer (normals of 68°) commences somewhat before June 1 in southern Indiana but not until the second week of June in the northern half of the state. Hot summer (normals of 75° or higher) commences about the summer solstice in the southern one-eighth of the state, but not until after July 10 in the northeastern third. Autumn, if defined as the quarter between summer and winter in temperatures, commences about September 8. The daily normals fall below 68° in central Indiana, also about September 8, but notably later in the southern and earlier in the northern parts of the state. Cool autumn (daily normals below 50°) commences about a month after the autumnal equinox in northern Indiana, six weeks after in southern Indiana. The season of killing frosts commences about three weeks after the equinox in central Indiana, but four weeks after in southern Indiana. The first snow falls in central Indiana usually during the first week in November.

HISTORY OF SCIENCE

Chairman: JOHN S. WRIGHT, Indianapolis

Dr. W. E. Edington, DePauw University, was elected chairman of the Section for 1946.

A Brief History of the Department of Biology, University of Notre Dame

THEODOR JUST, University of Notre Dame

Faculty and Courses

The University of Notre Dame was founded on the site of an old mission known as Ste. Marie des Lacs (1830) by the Right Rev. E. Sorin, C.S.C., first President, who came here from Mans, France, by way of Vincennes on November 26, 1842. The Legislature of the State of Indiana granted its charter on January 15, 1844. Like other institutions of its time Notre Dame was then largely a liberal arts college. The so-called Scientific Department was not organized until 1864 and recognized as a distinct unit of the University. This department included courses in physics, chemistry, zoology, botany, mineralogy, geology and comparative anatomy.

The formal teaching of biology, however, preceded the formation of the Scientific Department by many years. "Early records show that 'the Council of Professors' on June 7, 1844, appointed Brother Augustine, C.S.C., to teach botany and zoology." The Bulletin for 1859-60 gives the name of J. E. Tallon, M.D., as professor of physiology, anatomy and botany.

In 1863 Rev. Louis Neyron[1] was made professor of anatomy, physiology, and hygiene, but apparently did not begin teaching until the school year of 1866-67. Rev. Thomas L. Vagnier, C.S.C.,[2] was also appointed in 1863 as professor of botany as well as of chemistry and physics.

Thus the formation of the Scientific Department as a recognizable entity in 1864 was a mere formality, as science had been taught under the liberal arts program but the success of scientific subjects warranted their being set apart. Since 1867 all students followed the same Pro-

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[1] Rev. Louis J. Neyron, born probably in 1803, in France; missionary and famed physician in Indiana, Illinois, and Kentucky 1836-1863 when he came to Notre Dame; served in various hospitals during the Civil War; Professor of Anatomy, Physiology and Hygiene at the University of Notre Dame since the second session of 1866-1867; died Jan. 7, 1888.

[2] Rev. Thomas L. Vagnier, C.S.C., born March 22, 1839, at New France, near Fort Wayne, Ind.; entered Notre Dame in 1844, joined the community in 1855, Professor of Botany, Chemistry and Physics 1857-1874; died Aug. 1, 1926.

gram of General Science, or sequence of prescribed courses, which was later superseded by five different programs (1907) leading to a Bachelor of Science degree in Biology, etc.

In 1868, when Rev. C. B. Carrier, C.S.C.,[3] succeeded Father Vagnier as professor of botany, he also took over the directorship of the Scientific Department, now known as the College of Science. In addition, Rev. John A. Zahm, C.S.C.,[4] professor of physics, was appointed as assistant director. By that time there were also available four or five competent professors and the scientific course had made an excellent beginning. When in 1874 Father Carrier left for Texas and later for Canada, Rev. Alexander M. Kirsch, C.S.C.,[5] succeeded him and continued in this capacity until 1918. The term biology appears for the first time in the Bulletin of the University for the school year 1894-95, in which Father Kirsch is listed as professor of biology.

In 1870 a "partial course in medicine" was introduced and a medical department was recognized. Originally taught by Father Neyron, these subjects were taken over by local physicians, namely Drs. John B. Berteling, Francis J. Powers and Thomas A. Olney. By 1907 students were privileged to attend surgical clinics in the new St. Joseph Hospital of South Bend, Ind. As early as 1885 medicine was an optional study during the "Post-graduate Course."

The science of bacteriology appears for the first time in the Bulletin for 1879 in a statement that formal instruction in this subject is given and a completely equipped laboratory for the use of students was added to Science Hall in 1886. Also mentioned is a laboratory in photomicrography with an adjoining darkroom. Father Kirsch was the instructor in both of these subjects.

A notable development was the organization by Father Kirsch of the Laboratory of Cellular Biology, which was said to be the first labora-

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[3] Rev. Joseph Celestine Basile Carrier, C.S.C., born July 14, 1832, at St. Jouarre, France; arrived in America in 1855 and at Notre Dame in 1860; Master of Arts and Licentiate of Science; chaplain in Grant's Army from 1863 to 1865; trip to France in 1866; Director of Scientific Department and of the Museum, University of Notre Dame, 1867-1874; President of St. Mary's College, Galveston, Texas, 1874-1876; Professor of Natural Sciences, College St. Laurent, Montreal, Canada, 1876-1904; member of many scientific societies and contributor to various scientific journals; died Nov. 12, 1904, at Montreal, Canada.

[4] Rev. John Augustine Zahm, C.S.C., born June 14, 1851, at New Lexington, Ohio; came to Notre Dame in 1867, was soon appointed Professor of Natural Sciences, Assistant Director and later Director of the Museum; author of many books and articles on scientific subjects (*Evolution and Dogma,* 1896, etc.) and his travels; friend and travel companion of President Theodore Roosevelt, friend of President William Howard Taft; successful lecturer on scientific subjects; distinguished Dante scholar; planned and built Science Hall at Notre Dame; died Nov. 11, 1921.

[5] Rev. Alexander Marion Kirsch, C.S.C., born Sept. 11, 1855, at Clemency, Luxemburg; 1876-1918 Instructor in Natural Sciences, later Professor of Zoology, after 1877 Assistant Director of the Museum and later Director of the Museum; studied cytology at Louvain, Belgium, from 1879-1883; author of contributions to mammalian anatomy (*An Elementary Course in Mammalian Osteology,* Notre Dame, Ind., 1903), botany, cytology (*Cytology, or Cellular Biology,* published in The Microscope, vol. 11, Trenton, N. J., 1891), and mineralogy; died Jan. 15, 1923.

tory of its kind in the United States. Father Kirsch's lectures on this subject were published under the title *Cytology, or Cellular Biology* in the journal "The Microscope" (1891) and given also at the Cold Spring Harbor Biological Laboratory.

In 1904 Rev. Julius A. Nieuwland, C.S.C.,[6] became professor of botany and remained in that position until 1921. A student of the late Dr. Edward Lee Greene,[7] he was instrumental in bringing the latter to the University late in 1914. At that time Dr. Greene transferred his entire botanical library and herbarium to the University, where they are still housed. Dr. Greene's stay at Notre Dame was altogether too brief, as he died the next year, Nov. 10, 1915, and was buried at Notre Dame in the community cemetery. After Father Nieuwland had changed over to the Department of Chemistry the late Rev. W. Albertson, C.S.C.,[8] a former student of Father Nieuwland, took over the teaching of botany and bacteriology until his death in the spring of 1929.

Throughout these years the College of Science functioned in its original organization without separate departments until 1920, when it was reorganized and given its present form. The old course leading to a Bachelor of Science degree was dropped and specialization was required. Owing to the leadership of Father Kirsch the equivalent of the present Department of Biology was functioning long before the reorganization of the College of Science. When Father Kirsch retired in 1918 the late Rev. Francis J. Wenninger, C.S.C.,[9] took over the headship, to which duty he later added in 1923 that of Dean of the College of Science. He held both of these positions until his death on Feb. 12, 1940.

Since Science Hall had become too small, a new Biology Building was erected in 1936 and in the spring of 1937 the Department of Biology moved into it. Much new equipment is being added and all teaching facilities are thus constantly being improved.

So much for the general background of the administrative aspects and the general functions of the Scientific Department and its successors.

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[6] Rev. Julius Arthur Nieuwland, C.S.C., born Feb. 14, 1878, at Hansbeke, Belgium; Professor of Botany at Notre Dame from 1904 till 1921, Professor of Organic Chemistry from 1921 till his death; Dean of the College of Science, 1920-1923; died June 11, 1936; for additional data see Lyon, M. W., 1937—*Father Nieuwland the Botanist,* and for bibliography consult Amer. Midl. Natur. 17 (4): vii—xv, 1936.

[7] Edward Lee Greene, born Aug. 20, 1843, in Hopkinton, Rhode Island; Episcopalian minister and missionary in various western states; 1885-1895, Instructor and later Professor of Botany, University of California; Professor of Botany, Catholic University of America, 1895-1904; Honorary Associate in Botany, U. S. National Herbarium and U. S. Department of Agriculture, 1904-1914; University of Notre Dame, 1914-1915; honorary LL.D. from the University of Notre Dame in 1894; died Nov. 10, 1915; see also H. H. Bartlett (1916) and E. D. Kistler (1936).

[8] Rev. George W. Albertson, C.S.C., born Oct. 1, 1886, near Kalamazoo, Mich.; Professor of Botany and Bacteriology, Dean of the College of Science 1927-1929; died June 7, 1929.

[9] Rev. Francis Joseph Wenninger, C.S.C., born Oct. 27, 1888, at Pamhagen, Austria; Professor of Zoology and Head of the Department of Biology, 1918-1940, Dean of the College of Science from 1923 till 1927, 1929 till his death, Feb. 12, 1940; see also Amer. Midl. Natur. 23 (2): viii pp., 1940.

Let us now consider some of the aspects of the work done in these early days both by students as well as faculty members.

United Scientific Association

The *United Scientific Association,* subsequently known as the *Notre Dame Scientific Association,* was founded on May 12, 1868, with Rev. J. C. Carrier, C.S.C., as President, "for the furtherance of scientific objects." The membership of the association was restricted to "students of the very highest grade." It had three departments, viz., natural history, physics, and mathematics. By Feb. 16, 1869, it had 25 members, 17 of whom were considered active. Its activities included professorial Lectures, debates and lectures by students on scientific subjects, "exploration parties" (now known as field trips). The association also maintained at that time a library of 77 volumes and subscriptions to "three solid scientific periodicals." Its modern equivalent is the *Notre Dame Academy of Science,* founded in 1926 by the late Dean Wenninger. This Academy is likewise restricted to honor students in the College of Science.

Science Museum

In Mr. M. R. Keegan's report of the first commencement at Notre Dame, Aug. 1, 1845, published in the Philadelphia Catholic Herald of Aug. 28, 1845, he reports: "But the greatest rush was to the hall occupied by the splendid museum lately purchased by the institution from Dr. Cavalli, of Detroit, who had been collecting it at great expense for many years. It is a splendid collection of beasts, birds, fishes, reptiles, antiquities, etc., from various parts of the globe."

We also know how the Museum was secured. "Father Sorin owned a couple of lots in that city (Detroit) and made a trade with Dr. Cavalli." In 1865 adequate space could finally be provided for the growing Museum which was placed under the care of Father Carrier, its first real curator. Thus Father Carrier may well be regarded as the founder of the Science Museum at Notre Dame. Among other contributions he made himself by his ardent collecting, he encouraged students to collect for the Cabinet of Natural History and Comparative Osteology or the Mineralogical or the Geological Cabinets. While traveling in Europe in 1866 Father Carrier secured a great deal of material for the Museum, for example as gifts the following items: a six-inch telescope presented by Emperor Napoleon III, over five hundred books and twenty large boxes of specimens. In 1876 the Cabinet contained birds, quadrupeds, stuffed and lithographed in colors, native and foreign plants, in excess of 14,000 specimens. Present were also collections of minerals, fossils from "all geological formations," shells, insects and reptiles, eggs and nests, and Dr. Boyd's large collection of skeletons which had been on exhibition at the Inter-State Exposition in Chicago (1877). Father Carrier himself had collected some 8,000 specimens of plants. In 1876 a Mr. Otto, a professional taxidermist as far as the reports go, came from Chicago to supervise the mounting of some of the specimens. Father Zahm,

Curator since 1874, contributed many items collected by himself and solicited from students and friends. By 1878 the Museum was apparently one of the better collections of its kind at that time. Unfortunately, "In the fire of 1879 at the University the entire collection was destroyed, with exception of a single specimen—a mounted wolf—which had been taken out of the museum for renovation."

The rebuilding of the Museum was begun in 1880. Rev. D. Clarke, of Columbus, Ohio, presented the Museum with a collection of minerals and fossils. Former students and friends continued to send specimens to the Museum and additional purchases helped to restore the lost collections. In 1883 Science Hall was built and the Science Museum was transferred to new and spacious quarters in it. It has been there ever since.

Botanical Garden

In the spring of 1867 Father Carrier laid out a little botanical garden west of the old church, and in 1872 he developed a larger garden at the east end of St. Joseph's Lake. It is quite likely that this larger garden was the first real botanical garden developed in Indiana.

Botanical Collections
(Libraries and Herbaria)

The first major botanical collection of European plants was given to the University by the French botanist Cauvin, for many years President of the French Institute. Another valuable collection of New Zealand plants, principally ferns, was donated by a missionary, Rev. S. Barthos. This herbarium was augmented with American collections by Father Carrier and later by Father Kirsch (since 1874). By 1877 the herbarium contained between 4,000 and 5,000 specimens. Needless to say, this first herbarium was destroyed in the great fire of 1879.

Meanwhile Father Carrier had left the University but had continued his botanical studies in Canada. His work was publicly recognized by the award of a diploma by the Commissioner of the Chicago World's Fair in 1892, and similarly during the same year for a collection of Canadian plants at the Provincial Exhibition of Montreal. These collections are still largely represented at Notre Dame. Father Kirsch too collected with great ardor and added many specimens to the herbarium. Collections of tropical woods and fruits as well as many cryptogams are still housed in the Museum. After 1904 Father Nieuwland began his extensive botanical studies and built up the collections to an unprecedented level. By now this herbarium contains probably more than 50,000 specimens, many of which were received by exchange or gift. At the same time Father Nieuwland built up his rich botanical library with rare acumen and lasting devotion. This library now contains in excess of 3,000 volumes and is still growing.

A proud acquisition was the gift made to the University by Dr. Edward Lee Greene of his treasured library and irreplaceable herba-

rium. These came to the University in 1914 and, by the terms of the gift, must be kept as separate collections. This library is replete with pre-Linnaean works in botany, many of which are beautifully illustrated or otherwise valuable books. All in all, the library contains more than 4,000 volumes. The Herbarium Greeneanum is one of the most valuable collections largely of western American plants. As it includes the majority of types of the numerous new species of American plants described by Dr. Greene, it is indispensable in any serious taxonomic or monographic work. The herbarium is said to contain about 100,000 specimens.

It is worth mentioning in this connection that the Department of Biology has a third library, mainly of zoological and general biological books and journals. All told, some 10,000 books in all fields of biology are thus available for the reader.

The American Midland Naturalist

Founded in April, 1909, as the *Midland Naturalist* by Father Nieuwland at the suggestion of Dr. Greene, the journal was renamed the *American Midland Naturalist* before the year was out. Under this name it has appeared without interruption ever since. In the early years of its existence Father Nieuwland issued with it reprints of rare works in natural history, viz., all by LeConte and Rafinesque. In 1944 a new supplementary series, known as the *American Midland Naturalist Monograph Series*, was initiated by the author.

Conclusion

Much is being done at the present time to increase the facilities of the Department and to enlarge its scope of teaching in the undergraduate and graduate levels. Well founded on its great tradition and aware of progress in the field, the Department looks forward to greater service to Notre Dame and thereby to the Nation.

Acknowledgements

For assistance in locating references and information the writer is greatly indebted to Mr. Chas. C. Deam, Bluffton, Ind.; to Mr. Paul Byrne, Librarian, and Miss Eileen Conley, Reference Librarian, of the University of Notre Dame.

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Living Indiana Scientists, A Statistical Study

H. E. Zabel and Stephen S. Visher, Chicago, Ill., and Indiana Univ.

The seventh, 1944, edition of "American Men of Science" contains sketches of 655 scientists living in Indiana, 1,288 scientists who were born in Indiana and 1,215 collegiate alumni of Indiana colleges and universities. Indiana universities conferred the doctorate upon 334 scientists and the Masters or Engineering degree upon 172 who have not received a doctorate. These several groups, subtracting duplicates, total 2,304 living Indiana scientists. An additional 349 scientists now living elsewhere were faculty members in Indiana.

Of the 655 scientists living in Indiana in 1943, slightly more than two-thirds are connected with universities and colleges; one-fifth are with industrial firms.

Purdue University with 198 sketched scientists has nearly one-third of the scientists in the state, and nearly one-half of those connected with educational institutions. Indiana University has 97, Notre Dame 39, DePauw 18, Butler 13, Rose Polytechnic 9, Valparaiso 9, Ball State 8, Earlham 7 and Wabash 7. Four colleges have 5 each: Goshen, Hanover, Manchester and Indiana State Teachers. Taylor and Franklin each have 4, Indiana Central and Evansville 3 and Marion 2. Seven colleges have one each (Huntington, Kokomo Jr., Oakland City, St. Francis, St. Joseph, St. Mary-of-the-Woods, and Tristate).

The industrial concerns with most sketched scientists are Eli Lilly 30, Standard Oil of Indiana 29, Commercial Solvents 16, Mead Johnson 9, Servel 7, Pittman-Moore 5, Reilly Tar and Chemical 3.

Indiana has a larger percentage of its sketched scientists employed by industrial concerns than is true for most states, because Indiana is more highly industrialized than are most states.

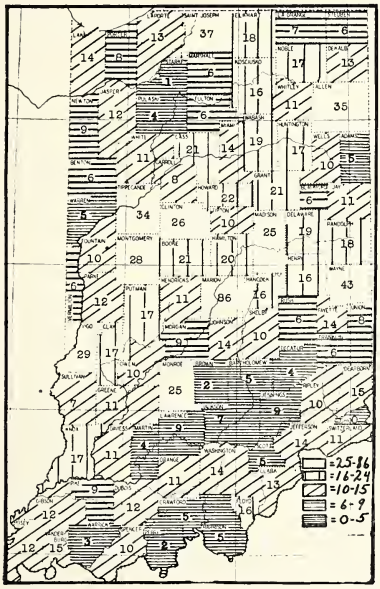
Birthplace of Scientists Born in Indiana

Indiana is given as their native state by 1,288 scientists sketched in the 1944 edition of "American Men of Science." Only six states yielded more, New York, Pennsylvania, Ohio, Illinois, Massachusetts, and Iowa. All but Iowa of these six states have notably larger populations than does Indiana. The states which rank eighth and ninth in the number of native scientists are Michigan and Wisconsin, both of which have about 200 fewer native scientists than Indiana.

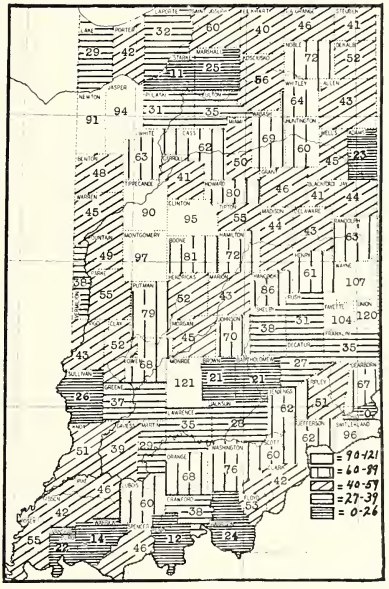
Between the 1938 and 1944 editions of "American Men of Science," Indiana increased its contribution of scientists by 15 per cent, a greater increase than that of the total population. At about the average date of birth of the 1938 group, Indiana yielded 473 scientists per million population. For the 1944 group, the yield had increased to 494 per

million. Both of these yield figures are relatively high as compared with the larger sections of the country, except New England. The yield of the South was 173 per million, of the North Atlantic States 400, of the North Central States 448, of the Rocky Mountain and Pacific States 470. Indiana's relatively high yield reflects several conditions, including the presence of relatively few negroes or other colored people, very few of whom have been recognized as scientists.

The birthplace by counties of the 1,265 scientists who gave their birthplace adequately to permit county location is shown on Map 1. The 22 counties which yielded most are Marion with 86, Wayne 43, St. Joseph 37, Allen 35, Tippecanoe 34, Vigo 29, Montgomery 28, Clinton 26, Madison 25, Monroe 25, Howard 22, Cass 21, Grant 21, Hamilton 20, Delaware 19, Wabash 19, Elkhart 18, Randolph 18, Clay 17, Knox 17, Noble 17, Putnam 17.



Map 1. Number of scientists sketched in American Men of Science 1944, born in each county.



Map 2. Yield of living scientists per 100,000 population in 1900 by counties.

Map 1 shows that none of the counties which produced 16 or more living scientists are in the southern part of the state, except Monroe, Knox and Floyd. Conversely most of the counties which yielded fewer than 10 scientists are in southern Indiana, but 10 such counties are in the northwestern part of the state and three in northeastern. Only the smallest county in the state (Ohio) yielded no scientist, and only one other (Starke) yielded only one. Brown and Perry each yielded 2.

In proportion to population at about the average date of birth of these scientists, which was about 1900, the rank of the counties is appreciably different. The 20 highest, in decreasing order, are Monroe, Union, Wayne, Fayette, Montgomery, Switzerland, Clinton, Jasper, Newton, Tippecanoe, Hancock, Boone, Howard, Putnam, Washington, Hamilton, Noble, Johnson, Wabash and Owen.

When mapped (Map 2), it is apparent that the high ranking counties are situated neither near the northern or southern margins of the state, except that Switzerland County ranks high. Three counties that produced more than one scientist per 1,000 of population at about the time of their birth are in the east, Wayne (Richmond) and its southern neighbors. Three other high counties, which produced one scientist to little more than 1,000 people, are Tippecanoe (Lafayette) and two neighbors. Other high counties are Monroe (Bloomington) and Newton, Jasper and Hancock. Most of the counties which produced 69-89 scientists per 100,000 people are close to the most productive counties. Exceptions are Washington (with Salem and Paoli) and Noble, whose noble name may possibly have helped some of its native sons to high achievement.

Five of the ten counties which yielded fewest scientists in proportion to population border the Ohio river. Three others are also in southern Indiana. Northwestern Indiana has, however, two counties which rank low and three others which rank relatively low. The central third of the state, north and south, contains no county which ranks very low and only one (Rush) which ranks relatively low.

These data on the yield of scientists in proportion to population when they were born indicates that the presence of a college where science is valued played an appreciable role. The counties where colleges were conspicuous in 1900 all rank high. Thus, Wayne, Montgomery, Monroe, Tippecanoe counties with Earlham and Wabash colleges, Indiana and Purdue universities, all rank in the upper tenth of the counties in yield. Putnam, with DePauw, also ranks in the upper one-sixth of the counties. Three other high counties are close to Purdue University (Clinton, Jasper, Newton). Another high county (Hancock) although it has no college, is situated not far from several colleges. Switzerland and Noble counties are the most conspicuous exceptions to the rule that the high counties either have a college or are relatively close to one.

Although most of the college influence in increasing the yield of scientists in proportion to population is due to educational stimulation, mention may be made of the fact that quite a number of scientists born in college towns are the children of professors.

Collegiate Alumni of Indiana

The A.B. degree or its counterpart was received by 1,215 persons sketched in "American Men of Science," 1944. Only seven states have more such alumni than has Indiana, namely New York, Massachusetts, Ohio, Pennsylvania, Illinois, California and Michigan. These states all

have considerably larger college populations than does Indiana. It may be noted that Iowa, which was the birthplace of 4 more scientists than Indiana, falls behind Indiana in the number of scientific collegiate alumni. Conversely, Michigan and California, which were the birth-states of fewer scientists than was Indiana, have more alumni scientists.

The fact that Indiana was the birthplace of 1,288 scientists but conferred college training on 1,215 shows that 73 more embryo scientists went elsewhere for their college training than the number that came to Indiana colleges from other states. A comparable situation occurs in several other states, notably New York, Pennsylvania, Iowa, Missouri, New Jersey, Illinois and Kentucky. This shows that Indiana has failed somewhat to afford adequate educational facilities for future scientists, but Indiana has failed less badly than several other states have done. States that have afforded collegiate training to many more than their own native scientists are Massachusetts, California, Michigan, Connecticut and Washington.

The leading Indiana institutions in the collegiate training of these scientists are Indiana University with 331 such alumni, Purdue 253, DePauw 138, Wabash 95, Earlham 71, Valparaiso 64, Butler 54, Notre Dame 42, State Teachers 36, Manchester 22, Rose Polytech 22, Hanover 20, Franklin 14, Indiana Central 11, Goshen 9, Evansville (Moore's Hill) 9, Oakland City 8, Taylor 5, Marion 5, Tristate 4, St. Joseph 2, Huntington 2, Rochester 1.

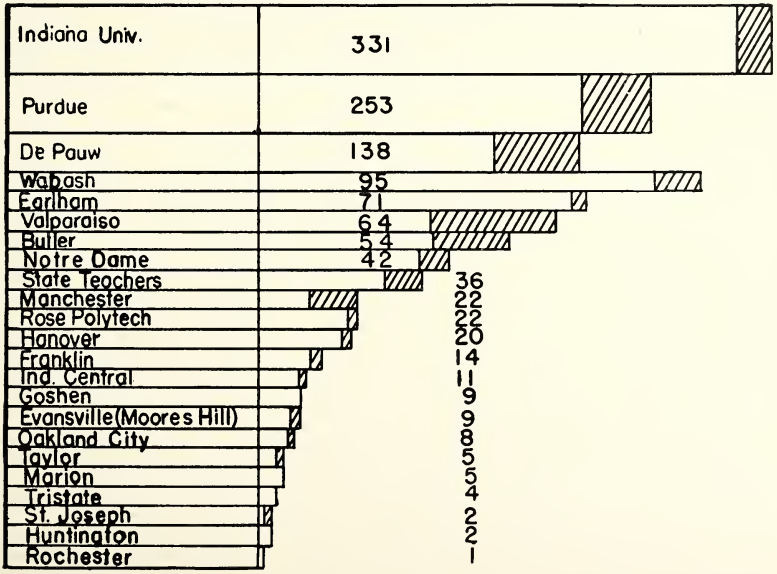


FIG. 3 NUMBER OF COLLEGIATE ALUMNI SKETCHED IN AMERICAN MEN OF SCIENCE 1944

SHADED PART SHOWS THE INCREASE OF 1944 OVER 1938 EDITIONS

In proportion to the number of their alumni, several of the smaller schools, notably DePauw, Wabash, Earlham and Valparaiso, have started more scientists than have either Indiana University or Purdue. This is partly because many Purdue alumni became engineers or farmers, and many Indiana University alumni became lawyers, physicians or high school teachers, a few members of which groups win recognition as scientists.

The increase in the number of alumni sketched in the 1944 edition over the number sketched in the 1938 edition is of interest. Purdue's increase was 44, DePauw's was 35, Valparaiso's 27, Indiana University's 24, Butler's 15, Manchester's 11, Wabash's 10, Notre Dame's 8, State Teacher's 8, and Earlham's 3. (Fig. 3.)

As compared with universities and colleges in other states, five Indiana institutions rank among the nation's leading 100 in the number of college alumni sketched in "American Men of Science" 1944. Indiana University holds 20th place in the nation, Purdue 25th, DePauw 46th, Wabash 66th, Earlham 97th. This is despite the fact that five of the eight universities which rank highest in scientific alumni are situated close to Indiana and are relatively accessible to Indiana students. These five are the Universities of Michigan, Wisconsin, Illinois, Chicago and Ohio with the following numbers of collegiate alumni sketched in "American Men of Science" 1944: 849, 832, 786, 661, 640. Other relatively high ranking schools near Indiana, with the number of their living alumni recognized as scientists, are Michigan State 241, Oberlin 233, Northwestern 186, Cincinnati 133, Ohio Wesleyan 119, Miami 115, Western Reserve 81, Ohio U. 79, Denison 75, Wooster 75 and Case 75.

Specialties of Indiana Scientists

Chemistry has attracted far more Indiana scientists than any other field. About one-fourth of the scientists born in Indiana became chemists, as did slightly more than a fourth of the collegiate alumni; nearly half of those who received doctorates in science in Indiana majored in chemistry. About 30 per cent of the scientists in Indiana in 1943 were chemists.

Physics ranks second to chemistry as a scientific choice, with somewhat more than a third as many devotees. Next comes botany, followed by mathematics, zoology and geology. The numbers in each of these and various other sciences are given in Table I.

Table I reveals that for several sciences, Indiana schools trained more future specialists than were born in Indiana. This was true for botany, plant pathology, pharmacy, anatomy and civil and mechanical engineering. Conversely Indiana has sent to other states for their callege training more future specialists than have trained in Indiana in agronomy, geology, mathematics, entomology, plant physiology, forestry, pathology, medicine, astronomy and chemical engineering. Since considerable numbers of men have been trained in Indiana in these fields without later winning recognition as scientists, it appears that the training was less stimulating in these sciences than in some others.

Among the 334 doctorates received in Indiana by subsequently recognized scientists, there are, in addition to the 151 in chemistry already mentioned, 58 in physics, 19 in zoology, 15 in botany, 15 in geology, 14 in mathematics, 13 in psychology, 13 in pharmacy and 7 in physiology.

The percentages of the scientists sketched in "American Men of Science" 1944 who specialized in each of the more popular sciences has

	Native	A.B. Alumni	Ph. D.	Other Final Degree	Tempor.	Now in Indiana
Chemistry	188	194	71	16	78	105
Phys. Chem.	34	31	22	1	11	22
Organic Chem.	52	54	50	3	15	41
Bio. Chem.	23	24	7	2	3	17
Physiol Chem.	12	8	1		3	4
Agric.	12	7		1	5	4
Agronomy	18	11	1		3	7
Animal Husb.	19	17	1	4	5	11
Physiology	28	27	7	1	3	11
Physics	119	117	58	13	43	55
Mathematics	74	66	14	8	40	54
Geology	52	32	15	4	10	16
Metallurgy	12	13	2	5	5	6
Psychology	57	57	13	2	18	33
Zoology	71	66	15	4	21	28
Entomology	18	13	2	1	9	14
Parasitology	6	5	2			4
Ecology	8	6	1		1	3
Biology	21	17	3	3	7	11
Botany	71	79	14	4	25	31
Plant. Physiol	20	11			4	5
Plant Path.	27	33	4	3	8	11
Horticulture	16	16	1	7	14	7
Forestry	6	3		1	3	3
Anatomy	18	20	1	2	4	7
Pharmacology	16	21	13	5	11	14
Pathology	11	3		1	5	6
Bacteriology	33	31	3	8	10	21
Medicine	32	16		10	3	10
Surgery	9	8		1		1
Med. Miscel.	19	15	1	3	3	5
Genetics	5	4	2		1	7
Soils	5	6	1	1	5	3
Nutrition	10	8		1	7	4
Astronomy	16	13	1	3	3	3
Geography	8	7	1		2	4
Eng. Misc.	29	32	1	14	16	19
Eng. Chem.	24	13	3	4	14	11
Civil	9	13		3	8	4
Elect.	16	15	1	11	7	7
Mech.	16	20	1	17	5	16
Miscellaneous	40	66	1	2	9	10
	1280	1218	334	172	445	655

TABLE 1 INDIANA SCIENTISTS CLASSIFIED BY SCIENCE AND OTHERWISE

been calculated for four other states as well as for Indiana. Some comparisons are of interest. Indiana with 27 per cent who are chemists exceeds Iowa, Minnesota, Massachusetts and Kansas, where from 24 to 19 per cent are chemists. In physics also Indiana, with 9.7 per cent leads.

	Industry	Colleges and Univs.	Governm't	Foundations and Museums	Private	Retired
Chemistry	205	164	39	4	9	4
Phys. Chem.	45	32	2			
Organic	89	49	7	2		
Bio. Chem.	17	26	6	1		
Physical Chem	6	9		1	2	
Agri.	3	14	2		1	
Agronomy		20	9			
Animal Husb.	5	31	3			
Physiology	1	41	1	1	1	
Physics	40	191	18	3	4	1
Mathematics	5	154	1	2	3	2
Geology	16	35	21	1	8	
Metallurgy	12	10	1	3	1	
Psychology	5	105	12		4	1
Zoology	2	108	10	4	5	1
Entomology	3	22	13		1	
Parasitology	1	5	3			
Ecology		9	3			
Biology	1	33	2		1	1
Botany	8	106	13	2	1	1
Plant. Physiol	3	20	4			
Plant Path.	4	34	12		1	1
Horticulture	2	27	8		1	1
Forestry		5	6			1
Anatomy		35				
Pharmacology	14	36	4			
Pathology	3	12	1	2	1	
Bacteriology	21	36	5	5	1	1
Medicine	4	26	5	1	5	3
Surgery		8	1		2	
Med. Miscel.	5	24	2			1
Genetics	1	13			1	
Soils	3	10	5			
Nutrition	3	13	2			
Astronomy		15	2	3	1	
Geography		13	1		2	
Eng. Misc.	20	40	10		7	1
Eng. Chem.	30	13	7	1	1	
Civil	1	21	3			
Elect.	13	22			2	1
Mech.	5	38				
Miscellaneous	4	41	9	1	5	1
	600	1669	254	37	71	22

TABLE 2 INDIANA SCIENTISTS CLASSIFIED BY EMPLOYMENT BY SCIENCES

Each of the other four states have about 6.4 per cent of their scientists in physics. Indiana also leads in botany (7.9), in which science Minnesota, Iowa and Kansas have about 6.5 per cent of their scientists botanists, and Massachusetts 5 per cent. In medicine, Indiana with 3.4 ranks close to Iowa and Kansas but far behind Massachusetts and Minnesota, each of which have 8 per cent of their scientists in medicine. Indiana also is behind in agriculture, zoology and geology. It is about average in engineering and slightly above average in mathematics and bacteriology.

Institutional Connections of Indiana Scientists

Of the 2,653 Indiana scientists here considered, 1,669 or 63.3 per cent were employed in 1943 by colleges and universities, 600 or 22.5 per cent were employed by industry, 254 or nearly 10 per cent worked for the government, 71 were privately employed, 37 were employed by foundations and museums, and 22 were retired. Of the 717 employed chemists, industry took 364, educational institutions 280, the government 54. Of the 256 employed physicists, colleges and universities took 191, industry 40, government 18. Only 5 of the 165 mathematicians were employed by industry in 1943, in contrast to 154 as teachers. Indeed, aside from chemists, physicists, engineers (68), bacteriologists (21), pharmacologists (14) and geologists (16), industry employed few of these scientists. Nevertheless, of the younger scientists, ever increasing percentage are employed by industry. (Table II.)

The 600 Indiana scientists employed by industry are connected with a total of 293 distinct firms of which 221 employed only one each, 32 employed 2 each, 13 employed 3, 7 employed 4, 4 employed 5, 5 employed 6, 6 employed 7-10. Only six firms outside of Indiana employed more than 6 Indiana scientists. These are Dupont 40, Standard Oil Research Co. 14, Dow Chemical 10, American Cyanamide 10, Montsanto 8, Abbott Laboratories 7; companies employing 6 are U. S. Rubber, R.C.A., Bell, Eastman, Alcoa. Only about one-tenth of Indiana's scientists are employed by one of the 13 large corporations which are especially conspicuous for their research activity (recently characterized by Secretary Henry A. Wallace as "dominating industrial research"). Why are not more Indiana scientists employed by these 13?

Age Distribution of Indiana Scientists

The median age of the Indiana scientists sketched in "American Men of Science" 1944 was 47 years in 1944. The oldest 29 were born before 1865, 316 or 12 per cent were 65 or older in 1944 and 7 per cent were 60-64. At the other extreme, 88 were born since 1914. Thus relatively few win the recognition of being sketched in "American Men of Science" before reaching 30. The Indiana botanists are older, on the average, than the chemists, mathematicians, physicists, bacteriologists, pharmocologists or geologists. Conspicuously young as groups are the organic chemists, physicists and geneticists.

Conclusion

Indiana has reared and trained relatively many recognized scientists, and has done conspicuously well with respect to some of the basic sciences. Although Indiana has done better in employing scientists than have many other states, more than half of the scientists reared or trained in Indiana are unable to find suitable employment in this state. This is especially true of the higher types of scientists, those

starred by secret vote of their fellow scientists as especially distinguished. Of this distinguished group, Indiana employs less than one-fifth as many as were born here. (Sixty-one living in 1943 were born in Indiana, only eleven resident here, and of these eleven, five had retired.) Also regretable is the fact that in several of the sciences, Indiana lags badly behind other progressive states. Such a factual presentation as here presented will assist, it is hoped, to correct these conditions.

MATHEMATICS

Chairman: JUNA L. BEAL, Butler University

The MATHEMATICS SECTION met with the Indiana Section, MATHEMATICAL ASSOCIATION OF AMERICA.

Professor H. E. Wolfe, Indiana University, was elected chairman of the Section for 1946.

Statistical methods for controlling the quality of industrial products. IRVING W. BURR, Purdue University.—Since industrial inspection data are statistical in nature, it is only to be expected that they may best be analyzed by statistical methods. The following tools are especially useful: frequency distributions, control charts, correlation and the laws of probability. It is the purpose of this paper to briefly show how these tools are used in practical applications, to suggest this field as a new and attractive career, and to point out that there are many unsolved problems.

Symmetry in metric spaces. PAUL M. PEPPER, University of Notre Dame.—In an abstract metric space S a point c is called a *center of pointwise-symmetry* if for each x in S there exists a point y(x) such that the distance xc equals the distance cy(x) and one-half the distance xy(x). *If* S *has at least* 2 *centers of pointwise-symmetry, then* S *is unbounded.* A point c of S is called a *center of* η*-symmetry* (fractional symmetry) if $0 < \eta \leqslant 1$ and for each x in S there exists a point y(x) for which $xc = cy(x)$ and $xy(x) \geqslant 2\eta xc$. *For each positive* η *less than* 1 *there exist bounded metric spaces of arbitrarily small diameter with* 2 *centers of* η*-symmetry.* (Examples related to the Chebychef polynomials of second kind are shown for each η less than 1.) A point c of S is called a *center of pointwise-open-symmetry* if for each number $\eta > 0$ and each x in S there exists a point $y(\eta,x)$ such that $xy(\eta,x) \geqslant 2xc - \eta$ and $|cy(\eta,x) - xc| \leqslant \eta$. *If* S *has at least* 2 *centers of pointwise-open-symmetry, then* S *is unbounded.*

PHYSICS

Chairman: R. E. MARTIN, Hanover College

Professor K. W. Meissner, Purdue University, was elected chairman of the section for 1946.

Theoretical calculations regarding electron accelerator. E. S. AKELEY, Purdue University.—In the accelerator patented by Hansen in 1937, energy is imparted to an electron by letting it pass a number of times through a cavity resonator. Woodyard thought of modifying this arrangement by placing a number of such resonators end to end and removing the inside end plates, thus forming a wave guide closed at both ends. He showed that electrons of several hundred million volts could be produced, and pointed out that the cost of such an accelerator should increase approximately proportional to the voltage, while the cost of accelerators of the type of the cyclotron or betatron would increase approximately proportional to the cube of the voltage, so that for particles of very high energy, the linear accelerator should be cheaper than the other type.

One of the most important considerations in the design of a linear accelerator is the shape of the cavity, which must produce a longitudinal electric field with which the electron is always in phase. Also the energy dissipation due to the finite conductivity of the walls of the guide should be as small as possible. For this purpose the stationary electro-magnetic modes that can exist between two infinite parallel conducting planes of infinite conductivity have been studied. The relative intensity of the modes excited can be fixed by connecting the planes by a conducting surface of revolution of infinite conductivity. The mode required to accelerate the electrons is the one whose wave length along the axis of the guide is equal to the wave length of the same radiation in the absence of the planes. If only this mode is excited, the conducting surface of revolution must meet the planes at infinity. However, if this mode and one other mode is excited, the surface can be chosen finite. The general character of surfaces of this type are discussed. Numerical integration is used to compute their shape quantitatively and to determine the energy dissipation.

Jet Propulsion. ROBERT D. BECKMAN, Allison Division of General Motors Corporation.—In this paper jet propulsion is shown as a practical application of a fundamental law of physics which has been known for over two thousand years. Several gadgets, model airplanes on a wire, and a small race car on a track feature the demonstrations. Also, a series of slide films designed to give a clear idea of the jet propulsion principle are used.

A Two Meter Grating Spectograph. JESSE B. COON, Bloomington.—A two meter grating spectrograph having an Eagle type mounting has

been designed and built. Some of the mechanical features of the mounting will be described. A method of obtaining a good intensity of 2100A radiation in the fourth order without overlapping will be discussed.

The structure of tellurium as a function of temperature. L. G. DOWELL AND J. ORNDOFF, Purdue University.—Experiments on electrical conductivity, Hall effect and thermo-electric power of tellurium show a behaviour not to be understood on the basis of a simple metal or semi-conductor structure. To investigate this problem in connection with possible changes in structure Lark-Horovitz suggested:

a. Structure investigation of tellurium layers produced and investigated in a high vacuum.

b. Tellurium deposited in a high vacuum but heated in air to various temperatures.

c. Tellurium powder heated in air at 200° and 400°.

The results show that

a. A vacuum deposited layer kept in vacuum all the time shows no change in structure throughout the whole range of temperature investigated.

b. There is no change in the vacuum deposited layer heated in air up to 200°. After heating to 360° in air, new lines appear which are not tellurium but fit some of the tellurium oxide lines or some more complicated pattern.

c. Tellurium heated in air up to 200° shows no change, but after heating to 360° or 400° for an hour and one-half, a whitish deposit appears and the powder then reveals diffraction lines which are identical with the ones obtained under b.

This shows that any theoretical explanation of the electrical properties of tellurium heated in air has to consider the existence of additional layers of material, and electrical investigations of tellurium deposited in a high vacuum and investigated also in high vacuum are necessary to decide the question whether the complicated electrical behavior is due to a complicated structure in the level of electron donators or acceptors themselves, or whether one is dealing with a mechanical mixture of the semi-conductor tellurium and an oxide or other compounds.

Refractions in a Compound Lens. MASON E. HUFFORD.—It is shown that a thick lens can always be found which has the same cardinal points as a comopund lens. The formula of a thick lens is developed using a new algebraic method. New geometric methods of showing the relationships of the cardinal points of a thick lens to its radii of curvature are developed. These relationships are applied in the case of a solid spherical lens.

Electron-diffraction study of the "polish layer." K. LARK-HOROVITZ AND T. S. RENZEMA, Purdue University.—In a study of polished surface we investigated beryllium, boron, germanium and silicon surfaces. We have obtained from these surfaces electron diffraction patterns appar-

ently identical with the patterns obtained from polished metal surfaces by many investigators. Beryllium and boron were chosen by reason of their small atomic radii to challenge the view that the "polish pattern" indicates that the polish layer is an amorphous state of the substrate.

The pattern obtained from polished silicon is not that to be expected from extremely small silicon crystallites nor can it be attributed to SiO_2 amorphous or crystalline. Washing a polished silicon surface in a hydrofluoric acid solution produces a weak silicon powder pattern suggesting the polished surface may be composed of finely divided silicon (insoluable in HF) and materials which are soluable in HF (polishing debris of silica or silicates.)

If a polished silicon surface is heated in air, a surface is produced which is visibly and electrically different from a surface which has been only polished. This surface, however, gives the same pattern as the latter surface even during a progressive removal by etching. Electron diffraction evidence suggests that the heat treatment oxidizes the fine silicon particles which seem to be included in the polish layer. K. Lark-Horovitz and K. W. Meissner have shown by optical methods that the layer formed when polished silicon is heated in air is definitely SiO_2, or a silicate.

Electron diffraction patterns produced by absorbed films of diffusion pump oil and other oily materials have been studied and the effect of rubbing such films observed. Various degreasing solutions and techniques have been tested.

Recent developments in the use of the atomic beam in spectroscopy. L. G. MUNDIE, Purdue University.—With the development of spectral apparatus having a resolving power of several million while still retaining a considerable spectral range, the need for a light source capable of emitting lines of very small width becomes apparent. The atomic beam is ideal for this purpose, for the Doppler broadening may be reduced at will by simply increasing the collimation of the beam. Line widths comparable with the natural width of the spectral line may be achieved in this way.

An atomic beam light source has been developed and is described in some detail. The problem of power dissipation in the grid has been solved by making the elements of fine nickel tubing through which distilled water is forced. The relatively high vacuum needed is achieved by independent pumping of the furnace and excitation chambers.

This apparatus has been used successfully in the case of Sn, Pb, Cd, Mg, Ca, and Al. In the case of Mg the hyperfine structure of many of the lines has been carefully investigated using Fabry-Perot interferometer, and the theoretical interpretation of the results are discussed. Intensity anomalies present within a p-p' multiplet in the case of Mg were not present in the corresponding multiplet of Ca. The investigation of Al by this method presents greater difficulty with respect to furnace construction. While the results are not yet complete, they should be of considerable theoretical interest.

Significance of symbols in physical equations. DUANE ROLLER, Wabash College.—According to Bridgman, physical symbols always denote numbers. Wallot (1926) and Lenzen (1940) are among those who contend that the symbols may represent physical quantities directly. Difficulty in converting certain electrical equations from a rationalized to a nonrationalized form has been interpreted as indicating that the symbols involved must necessarily represent numerical values only. However, an analysis indicates that this interpretation is incorrect. Any physical equation can be written either between physical quantities or between numerical values. The only requirements are consistency and unambiguity in the use of one scheme or the other.

A quantitative method for the spectroscopic anaylsis of potassium-sodium solution. WAYNE SCANLON, Purdue University.—A rapid and accurate method of quantitative analysis of sodium and potassium was developed which gives direct measurements of concentrations ranging from 10 mg/100 cc. to 200 mg/100 cc. The solution containing the sodium and potassium is sprayed into a flame where the resonance lines of these elements alone are appreciably excited. The resonance lines of sodium at 5890 and 5895 A° and those of potassium at 7664 and 7699 A° are separated enough in the spectrum to permit their isolation almost completely by means of color filters. The light from the flame is by this means separated, one color falling on a red sensitive photo-electric cell and other on a yellow cell. The photo electric current is measured by means of a high sensitive galvanometer.

The illumination gas and air mixture that gave the most stable conditions were determined. These could be maintained steady enough to permit calibration of the galvanometer scale in terms of concentrations of potassium and sodium.

The amount of solution required is small, as little as 1 cc. being sufficient. The results obtained on test solutions showed errors not greater than about 3 per cent to 5 per cent.

Some remarks on the focussing of ions in a magnetic field. W. M. SCHWARZ, Indiana University.—The focussing properties of magnetic fields of various shapes are known. In particular the properties of a sector shaped filed have bene worked out by Stephens for the case of electrons. The equations are readily adapted for mass spectrograph work, and some interesting conclusions can be drawn from them after their form has been modified.

Radiation from an Electron Using the Formula, H=Curl Idl/r.

R. R. Ramsey, Indiana University

The formula, H= Curl Idl/r, which first came to my attention in an article by J. H. Dellinger (Scientific Paper of the Bureau of Standards, No. 354) applies to all aerial circuits used in radio transmission. The thought came to me to see how it would apply to an electron while radiating energy. When applying this formula to a radio circuit we assume that the term Idl/r has the components IdX/r, IdY/r and IdZ/r parallel to the three axes. The curl equation can be written in several ways. I shall write it as follows:

$$H_x = d/dy\ (IdZ/r) - d/dz\ (IdY/r)$$
$$H_y = d/dz\ (IdX/r) - d/dx\ (IdZ/r)$$
$$H_z = d/dx\ (IdY/r) - d/dy\ (IdX/r)$$

Taking the simple case of a vertical aerial the current is all in the Y direction and all terms are zero except the last part of the H_x equation and the first part of the H_z equation. If the point, P, in question is placed in the XY plane the first of these two drops out since z is zero. Since our radio current is alternating current our expression for the current, I, becomes $I_o \sin w(t-t')$, where t' is the time required for the disturbance to travel from the aerial to the point, P. The time, t' is equal to r/c. Where r is the distance and c is the velocity of light.

Then H_z or $H = d/dx\ (I_o dY/r) \sin w(t-r/c)$. Since $r = (x^2+y^2+z^2)^{1/2}$ the quantity, x, is involved in r and in differentiating the equation there will be two terms. Differentiating we get $H = -(I_o dy/r^2) \sin w\ (t-r/c) \cos \theta - (I_o dY/r\ wc) \cos w(t-r/c) \cos \theta$.

The first term or the sine term is induction and varies inversely as the square of the distance and is time phase with the current. The second term or the cosine term varies inversely as the first power of the distance. The first term is due to the velocity of the electron and the second term is out of phase with current and may be said to be due to the acceleration of the electron.

It can be shown that these two components have the same numerical value at a distance of $\gamma/2\pi$ from the areial. This is about one-sixth of a wave length and at a distance of a wave length or more the field is all radiation since for practical purposes induction is zero in comparison.

We may assume we have an electron vibrating harmonically in the Y, or vertical direction at the origin of the axes. The charge, e=Idt. Multiply both sides by dl and divide both sides by dt and we have, e dl/dt=Idl. Or Idl=ev. Where v is the velocity of the electron. If the electron is vibrating we have, $v = v_o \sin wt$ at the origin and $v = v_o \sin w(t-r/c)$ at the point, P.

Differentiating this last expression with respect to t we get the acceleration, $a = v_o w \cos w(t - r/c)$.

If one substitutes ev_o for $I_o dl$ and a for the above expression in the last half of radiation term of the above equation for the field, H we get, $H = (ea/rc) \cos \theta$ as the expression for the magnetic component. Since in e. m. c.g.s. units the electric field component, $E = Hc$, we have, $E = (ea/r) \cos \theta$. Since energy density is equal to $(1/4\pi)HE$, we have $(1/4\pi)\ (e^2a^2/cr^2) \cos^2 \theta$ for the energy per cubic centimeter. It will be apparent that the energy radiated or the field is symmeterical about the Y axis.

The energy radiated in one second will be located between a sphere of radius, r and a concentric sphere of radius $(r+c)$. The value of this energy radiated per second can be obtained by integrating over this volume the energy density as expressed above times dV. Where $dV = r \cos \theta\ d\phi\ r d\theta\ dr$.

Making the substitutions and indicating the integrations between the proper limits we get,

$$\text{the energy, } W = (1/4\pi)\ (e^2\ a^2/c) \int_0^{2\pi} d\theta \int_0^{\pi/2} \cos^2\theta\ d\theta \int_r^{r+c} dr.$$

Integrating with respect to ϕ between limits we get the expression multiplied by 2π. Integrating with respect to r we get the expression multiplied by c, when limits are used. Integrating with respect to θ we have for the upper hemisphere,

$$W = (1/2)\ (e^2a^2) \int_0^{\pi/2} (1 - \sin^2) \cos \theta\ d\theta = (1/2)\ (e^2a^2) [\sin \theta - 1/3 \sin^3 \theta]_0^{\pi/2}$$

$= 1 - 1/3)\ (e^2\ a^2)$ for the half sphere. For the total energy we have $W = 2/3\ (e^2\ a^2)$ ergs per second as the rate of radiation. Here e, is expressed in e.m. c.g.s. units. If e is expressed in e.s. c.g.s. units we have $2/3\ (e^2\ a^2/c^2)$.

J. J. Thomson "Electricity and Magnetism," p. 61, gives values for E and H which if integrated as above gives this result. Richardson "Electron Theory" p. 258 gives $e^2\ a^2/6\ c^2$. Dull and Plimton "Elements of Electro Theory" p. 167 gives $2/3(e^2a^2/c^3)$.

PSYCHOLOGY

Chairman: W. N. KELLOGG, Indiana University

Professor C. C. Josey, Butler University, was elected chairman of the Section for 1946.

Action potential measurements from the arms in the foreperiod of reaction time to visual stimuli. WILLIAM ARNOLD LIVINGSTON, Indiana University.—Evidence has been reported by other authors both for and against the existence of changes in action potentials during the warning-stimulus interval in the reaction time experiment. Data reported arise from investigation of action potential changes in the interval between the ready signal and stimulus presentation under conditions of simple and choice reaction time to visual stimuli. Work is a contribution to the physiological psychology of simple and complex set.

The relationship between perceptual span and rate of reading. JEAN SUTHERLAND, Butler University.—The purpose of this investigation was to determine (1) the relationship between perceptual span and rate of reading; and (2) the effect of systematic training in perceptual span upon rate of reading and upon improvability in rate of reading. A subsidiary objective of the investigation was to determine the relationship between perceptual span and rate of perception.

Perceptual span was determined by a test consisting of 228 words and phrases presented one word or phrase at a time by means of a tachistoscope. The exposure was 100ms. The reliability coefficient of the test was .93. Correlations obtained between perceptial span and rate of reading as measured by three tests ranged from .31 to .37. Perceptual span and rate of perception correlated to the extent of r=.73. The subjects were 125 college students.

Two groups of university freshmen (N=36) were given training in perceptual span by the same method as the testing procedure described above, although different words and phrases were used. As a result of training the subjects made significant improvement in span and subsequently showed a significant gain in rate of reading. Thereafter this group of subjects was given training in reading, chiefly by the use of the Harvard Reading Training Films. Their progress was more rapid, presumably because of their prior basic training in perceptual span, than that of control groups that did not have this basic training.

Modification of Reflex Behavior in Spinal Dogs

James Deese and W. N. Kellogg, Indiana University

The first indication that relatively permanent changes in reflex behavior can take place in spinal preparations, aside from the effects of fatigue, was found by Prosser and Hunter (2). Following complete spinal transection of laboratory rats they found various spinal reflexes could be extinguished with stimuli repeated at intervals of from 10 to 15 seconds. The extinction was considered to be a central process. The process involved the gradual dropping out of "active units" and the diminution in the duration of the response. This was thought to indicate that extinction was a gradual lowering of the excitability.

Shurrager and Culler (4) reported the establishment of a conditioned response in the spinal dog. The spinal cord was completely severed near the third cervical vertabra. Both semitendinosus muscles (S-T MM.) were exposed and freed of fascial attachments, and then fastened to recording tambours. The conditioned stimulus, either mechanical or electric, was administered to the tip of the tail. It consisted of three short shocks or pressures given one second apart, the third one being presented simultaneously with the unconditioned stimulus. The unconditioned stimulus was a shock of sufficient intensity to evoke a full contraction of the left S-T M. when applied to the left paw. A conditioned response to the conditioned stimulus appeared within 25 to 50 trials (4). "The CR is much smaller than the UCR and is generally confined to a small area near the peripheral end of the muscle. The right muscle remains flaccid throughout" (4). Repeating the conditioned stimulus without the unconditioned stimulus resulted in extinction (3).

Pronko and Kellogg (1) found that there are two types of conditioned responses in shock-shock conditioning. One of the types of response having a much shorter latency is similar to the "conditioned response" observed in spinal dogs by Shurrager and Culler. This response, of smaller magnitude and briefer latency, does not conform to the more typical frequency curves of conditioned responses. It rises to a relatively high frequency early, but then does not increase much. This type of response was characterized by the authors as "a kind of flexing jerk or muscle twitch" (1) appearing in the limb to be conditioned shortly after the conditioned stimulus. This muscle twitch is distinctly different from both the unconditioned reflex and the conditioned reflex of the more usual type. Wendt (5) earlier reported a similar condition in conditioning the knee-jerk in human beings with the unconditioned stimulus being a blow to the limb opposite the one to be conditioned. This is, of course, analogous to shock-shock conditioning. The author interprets the bilateral type of response as being mediated by "a lower level integration." (5) This integration is thought to be already present before conditioning as revealed by the strong

facilitating effect of a blow to one knee on the response of the opposite knee. In an occasional individual a crossed-extension reflex is present instead. Repetition of the conditioning trials increases the bilateral secondary response more than the crossed-extension. The presence of the crossed-extension response in this type of conditioning bears important relation to the finding of the present study.

Operation and care of the animals. The use of morphine sulphate or other depressing drugs was strictly avoided, and ether alone was employed as the anesthetic agent. The purpose of this technique was to permit recovery from the anesthetic as quickly as possible. A skin incision about 3 inches in length was then made at the level of the third lumbar vertabra. The muscle tissue was incised by electrosurgery and the spinus and transverse processes of the spinal column were removed by rongeurs. The vertebrae above and below the third lumbar nerves were drilled with a dental burr and the dura exposed for a distance of about an inch. The cord was ligated in two places to prevent the loss of spinal fluid and was then completely transected between the ligatures. Sulphanilimide was placed in the wound and the muscle tissue and fascia were closed with interrupted silk sutures.

Since the animals were kept for about three weeks following the operation it was necessary to build a special device for keeping them active and healthy. A system was finally arranged which permitted a maximum degree of freedom without danger of the animal irritating his wound, or otherwise damaging himself. When not in the conditioning stock the animals were supported in a canvas sling attached to a metal frame from above. This could be raised and lowered, permitting the animal's legs to be on a level with the body or suspended from above, as needed.

Conditioning technique. Four animals were used in the experiment. Shock-shock conditioning was used in the following manner: Two conditioned stimuli were administered to the left rear paw, one second apart. The unconditioned stimulus was administered to the right rear paw one second after the last conditioned stimulus. All measurable upward changes in contour on the kymograph record occurring 9/5 of a second after the conditioned stimuli and before the unconditioned responses were considered conditioned responses in the animals before the operation. Frequency, latency and amplitude were measured in sessions recorded before the operations. Following the operation all changes in an upward dirction in the right rear leg simultaneous with the conditioned stimuli in the left rear leg were classified as "bilateral flexion" responses. All changes in a downward direction in the right leg simultaneous with the conditioned stimuli in the left rear leg were classified as "crossed-extension" responses. Only frequency of these responses was measured, since latency and amplitude were for all purposes the same throughout.

Results and discussion. Prior to the operation all four dogs were given extensive conditioning training, all animals but one reaching the criterion of 100 per cent frequency of conditioned responses in a 20

trial series. One animal, M74, reached only 85 per cent frequency on the last series. All the animals except M74 had previously been trained in this same conditioning technique, so the frequency on the first series represents retention over varying periods of time. M74 had been previously trained in a slightly different technique. Table I shows the percent frequency on each series for all four dogs. Following the operation

Table I

The Percent Frequency of Conditioned Responses in Right Rear Leg for Pre-Operative Training in all Four Dogs

Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
F54	70	60	95	50	50	55	100	100							
M74	45	20	45	55	30	65	80	85	70	60	75	95	75	70	85
M77	95	65	35	55	90	100									
M79	90	100	80	90	100										

1,000 trials were given to each dog, 100 trials on every other day. This necessitated keeping each dog for a period of about three weeks. After the operation the conditioned responses developed during the course of the pre-operative training disappeared. However two distinct kinds of responses appeared in the course of time during the presentation of the conditioned stimuli after the operation. One was a minute muscle twitch or bilateral flexion to the conditioned stimuli, bearing close resemblance to what Shurrager and Culler (4) called a conditioned response in their preparations. The other was a crossed-extension reflex to the conditioned stimuli. These two responses were mutually inhibitory to any given stimulus, but both appeared frequently in the same series. When the frequency of each was plotted graphically it did not resemble a conditioning curve, since both responses appeared and disappeared during the course of the experiment. This may be gathered from Table II and III. However they never appeared immediately on the first trials following the operation in any of the dogs.

In interpreting tables II and III one should consider the mutually inhibitory nature of the two responses to any given stimulus. Under the present conditioning procedure the crossed-extension reflex to the conditioned stimulus was not eliminated as it was in the Shurrager and Culler studies (3, 4). It is possible that the bilateral flexion response might have developed more characteristically if the crossed-extension reflex to the conditioned stimulus had been eliminated.

When the percentage frequency of the two responses are combined it suggests the development of a conditioned response of very low frequency. Table IV gives evidence of this. To the 17th series the frequency rises in a fairly regular fashion, after which it declines slightly to a more or less level position. It is extremely difficult to account for this unless one assumes a gradual restoration of physiological function following the operation. It will not do to attribute it to a gradual "spread of excitation" since there are distinctly two responses present,

Table II

The Frequency of Bilateral Flexion Responses in all Four Dogs Combined Following the Spinal Transection

Series	Per cent	Series	Per cent
1	0.	26	10.
2	3.76	27	21.2
3	7.5	28	13.5
4	0.	29	15.
5	1.25	30	10.
6	2.5	31	7.5
7	6.25	32	12.5
8	3.76	33	3.76
9	2.5	34	1.25
10	1.25	35	2.5
11	12.6	36	0.
12	21.2	37	2.5
13	13.5	38	5.
14	17.5	39	0.
15	12.5	40	1.25
16	0.	41	3.76
17	1.25	42	1.25
18	3.76	43	1.25
19	2.5	44	0.
20	5.	45	0.
21	1.25	46	2.5
22	1.25	47	2.5
23	0.	48	2.5
24	2.5	49	2.5
25	0.	50	2.5

now one appearing now the other. It is quite possible that one response is "inherent" to particular structural limitations here (the crossed-extension) and that the other (bilateral flexion) develops during the process of repeated stimulation. However the functional nature of most spinal reflexes makes an explanation of the *raison d'etre* extremely difficult. An explanation would be much easier if the bilateral flexion responses were isolated instances appearing in one preparation, or if they had not appeared under the same stimulus conditions in an intact animal (1). But there is no doubt of their genuine character and the fact that they are unstable (appearing and disappearing) reflexes, though the stimulating conditions remain essentially the same. The most likely hypothesis seems to be that they represent a kind of spinal analogue of startle responses in intact animals. Such an explanation would leave the role of the unconditioned stimulus doubtful. Shurrager and Culler (3,4) emphatically point to the role of the unconditioned stimulus in the appearance of these spinal "conditioned responses" since they are subject to extinction with the elimination of the unconditioned stimulus.

Table III

The Frequency of Crossed-Extension Responses in all Four Dogs Combined Following the Spinal Transection

Series	Per cent	Series	Per cent
1	0.	26	2.5
2	0.	27	2.5
3	0.	28	1.25
4	0.	29	1.25
5	0.	30	1.25
6	0.	31	7.5
7	2.5	32	11.2
8	8.75	33	7.5
9	20.	34	16.5
10	25.3	35	10.0
11	22.5	36	15.0
12	10.	37	15.0
13	8.75	38	22.5
14	8.75	39	21.2
15	28.8	40	3.76
16	32.5	41	17.5
17	25.	42	12.5
18	27.5	43	22.5
19	20.	44	16.2
20	13.7	45	7.5
21	8.75	46	13.7
22	13.7	47	16.2
23	8.75	48	20.0
24	13.7	49	16.2
25	12.5	50	15.0

To define "operationally" the appearance of such responses as a conditioning process is easy enough, but it leaves much to be desired. In the present study the responses developed, taken together, seem to bear no particular relation to the appearance of the unconditiond stimulus, but seem to depend entirely for their appearance on the conditioned stimulus. The bilateral flexion reflexes isolated may bear a more direct functional relation to the unconditioned stimulus, but in working with the particular arrangement of shock-shock conditioning used in this experiment it is impossible to eliminate the crossed-extension reflex and still keep the limbs of the animal intact. However, the appearance of both of these "muscle-twitch" phenomena seem to indicate a decided modification of reflex activity as stimulation is continued. However, if they are conditioned responses, as defined not only by the experimental procedure, but also by the measuring techniques used, then they are of a doubtful nature.

This bilateral flexion response seems to stand more or less in between the less variable type of response, such as a direct unconditioned response, and the modified or conditioned response. Modification

Table IV

The Combined Frequency of Bilateral Flexion and Crossed-Extension Responses in all Four Dogs Combined

Series	Per cent	Series	Per cent
1	0.	26	12.5
2	3.76	27	23.7
3	7.5	28	14.75
4	0.	29	16.25
5	1.25	30	11.25
6	2.5	31	15.0
7	8.75	32	23.7
8	12.51	33	11.26
9	22.5	34	17.45
10	26.55	35	12.5
11	35.1	36	15.0
12	31.2	37	17.5
13	22.25	38	27.5
14	26.25	39	21.2
15	41.3	40	5.01
16	32.5	41	21.26
17	26.25	42	13.75
18	31.26	43	24.75
19	22.5	44	16.2
20	18.7	45	7.5
21	10.0	46	14.95
22	14.95	47	18.75
23	8.75	48	22.5
24	16.2	49	18.75
25	12.5	50	17.5

of behavior here has taken place, but the frequency and temporal location were not predictable from any previously given conditions. The exact physiological conditions involved in this modification of response are unknown, and speculations are of little avail in the face of the complexity of the structures involved. However, the common conception of the stereotyped reflex behavior, unmodifiable except for diminution or disappearance upon repeated stimulation, seems seriously in need of revision. Whether the modifiability of the responses may be considered conditioning is another question. Certainly the status of the conditioned response, defined by its investigation, has yielded nothing directly comparable.

Summary. Reflex phenomena similar to the spinal conditioning reported by Shurrager and Culler (4) was found in four dogs after the spinal cord had been completely severed at the level of the 3rd lumbar vertabra. These responses were minute twitches in the limb contralateral to the limb in which the conditioned stimuli were delivered, being the same limb in which the unconditioned response appeared. These responses were intermingled and apparently inhibited by crossed-

extension reflexes to the conditioned stimuli. Both responses appeared, disappeared and reappeared in no regular sequence. There was no indication of incipient avoidance movements to the unconditioned stimulus, though all dogs had been trained to a high degree of proficiency in shock-shock conditioning before the operation. Whether this modifiability of response can be classified under the more customary canons of the conditioned response is doubtful. Rather these reflexes may represent a transition between the clear cut cases of learned responses and those reflexes which are relatively invariable and tied up with the existence of certain crucial structures.

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Retention of Nonsense Syllables over Short Intervals of Time

G. Raymond Stone, Indiana University

To those studies which have indicated the methodological inadequacy of the deductive type of theory proposed by Hull (3) for rote learning,* the present study should be added. The problem here is the investigation of the phenomenon of reminiscence and its measurement by latency as well as recall values, a problem occupying a central role in the Hull system.

Twenty-four college student subjects learned serial lists of 12 nonsense syllables by the anticipation method with a two-second rate of exposure per syllable, six seconds between trials. Each subject learned comparable lists under four counterbalanced experimental conditions and after two periods of practice learning. Each of the six sessions were one hour in length and on successive days. The control condition was continuous learning to two perfect recitations in succession. In the experimental conditions, rest pauses of two, five, or 20 minutes were inserted after partial learning: the first trial on which seven or more syllables were anticipated correctly. The subject named colors on specially prepared cards during the interval of no learning.

The latencies of the subject's responses were recorded kymographically through a microphone and amplifier system to signal markers which were reset by the mechanism of the drum turning. Complete verbal anticipation data were taken.

Results

The total number of correct responses on that trial in the control condition which followed the first trial having seven or more correct is used as the basis for comparing the recall scores in the experimental conditions after the insertion of rest periods. If reminiscence is present, the first recall trial of the experimental condition(s) must have a reliably greater value than the comparable trial in continuous learning. The data are presented in Table I.

The small increase in the mean recall score of the two-minute rest condition (2 in Table I) over the control condition (0 in Table I) is extremely unreliable and is not present at all in the five-minute rest condition (5 in Table I). Reminiscence, therefore, has not been demonstrated by mean recall scores under conditions supposedly optimal for its appearance (2, 6). This may well be merely a function of the high variability of scores and does not rule out the validity of the phenomenon.

* The present experiment is part of a larger work the remainder of which has been published elsewhere (5).

G. O. McGeoch (4) has suggested that mean recall scores may obscure the reminiscence effect because the subjects who gain in recall do not gain as much as an occasional subject may lose. She suggested a comparison of the number of subjects showing improvement with the number showing forgetting. An analysis of this type is presented in Table II. Although the evidence for reminiscence is supported by these data, the percentage differences lack statistical reliability.

Of all the suggested measures of reminiscence, the latency of response appears to be the most inadequate. Not only is the commensurable range of this variable extremely short (two seconds in this experiment),

Table I

Recall Scores on the First Trial After the Criterion of Partial Learning

	Experimental Condition			
	0	2	5	20
Mean recall	6.75	6.83	5.58	4.00
SEmean	.30	.30	.35	.25

	Mean Difference	S.E. mean diff.
Between 0 and 2	.08	.44
Between 0 and 5	1.17	.43
Between 0 and 20	2.75	.34

Table II

Number of Subjects Showing Improvement on the First Recall Trial After Partial Learning

	Experimental Condition			
	0	2	5	20
Recall Improvement	4	8*	3	0
Decreased Recall	12	8	18	24
Remained Same	8	8	3	0

but it is also subject to a number of determining conditions other than positive excitatory strength which Hull assumes as its major correlate. In any time controlled serial task involving subject reaction to material exposed for limited intervals, there is certain to be an influence of refractoriness to repetition as well as one attributed to the rhythm of presentation-response and its disruption. Both of these influences would tend to distort the latencies of the last portions of a serial task in the direction of greater latencies even though it is a well established fact in serial learning that excitatory strength increases from just past the middle to the end of the series.

* When improvement for the control and 2 condition are expressed as percentages, the percentage difference is .166; its S.E. is .123. N = 24.

If rest pauses are introduced, it is to be expected that latency values will recover to some extent but less in the latter portions of the series. This is contrary to the predictions of Hull who would have latency scores parallel those of excitatory strength as measured by recall successes in the series. The relevant data for recall scores on the first trial after rest are presented in Figure I, where the total number of recall failures are plotted as a function of serial position.

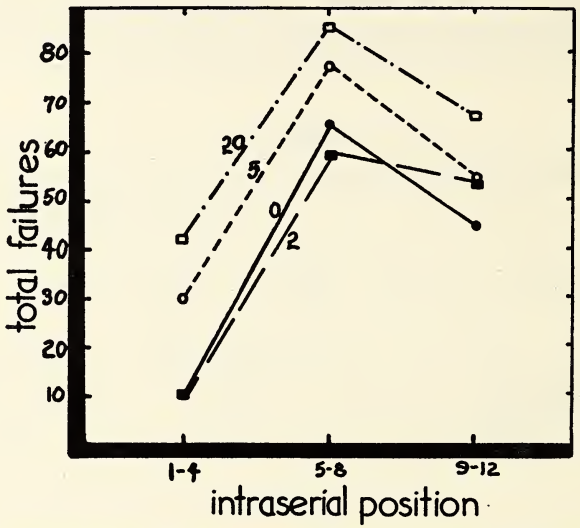

Fig. 1. Recall Failures as a Function of Serial Position. Grouped Data.

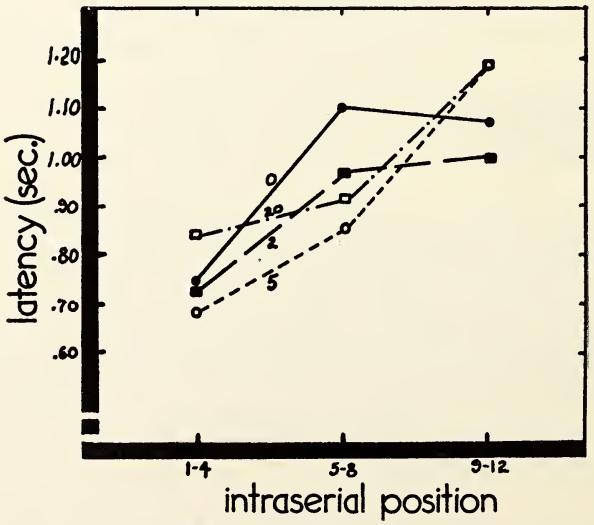

Fig. 2. Latency as a Function of Serial Position. Grouped Data.

The expected increase in excitatory strength in the latter portions of the series (as measured by decrease in recall failures) is evident. The control and 2-minute conditions are not reliably different.

In the case of latency values, however (Figure 2), it is to be noticed that latencies increased in the later serial portions in all experimental conditions even though they were shortened in the middle portions. The fact that the 20-minute rest condition is superior to the control reaffirms the view that latency values are determined primarily by factors other than excitatory strength; no one, to the writer's knowledge, has ever claimed reminiscence (under conditions similar to those used here) as late as 20 minutes after the cessation of formal practice (1).

Before latency values are used in the intricate machinations of deductive theory as a measure of the dependent variable (learning), it seems that a more exhaustive examination of that supposed dependent relation is in order. The present results indicate that latency may be an entirely different function of time interval duration than it is a function of excitatory strength as measured by recall.

Summary

Under experimental conditions supposedly optimal for the production of reminiscence—i.e., nonsense material exposed serially at a two-second rate, learned by the anticipation method, and with rest pauses of two and five minutes inserted after partial learning—the phenomenon was not reliably demonstrated by any of three techniques of measurement. The force of this conclusion is somewhat mitigated by the high variability of the data. It is suggested that latency of response is a poor variable to use as a measure of the dependent variation of learning behavior.

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ZOOLOGY

Chairman: W. R. BRENEMAN, Indiana University

Professor H. H. Vogel, Jr., Wabash College, was elected chairman of the section for 1946.

Determination of the life history of *Cercaria szidati*, a furcocercous larva of the Vivax type. DORCAS J. ANDERSON, Purdue University.—Further studies on *Cercaria szidati* Anderson, 1944, have revealed that the larvae penetrate and encyst in the muscle tissue of minnows, especially in the tail region. Several groups of newly hatched chicks were fed heavily infected minnows. In one series of five chicks, immature flukes were recovered five hours after feeding, and in another similar series, all chicks were passing fluke eggs three days after feeding. Two of the five were sacrificed and found to harbor 14 and 30 sexually mature worms respectively. The remaining three lost the parasites in less than a week. A Great Blue Heron nestling was infected to provide a continuous source of eggs for study of the miracidium. The adult worm is a species of *Linstowiella* similar to *L. viviparae* as described by Szidat, but the morphology of the cercaria and the type of second intermediate host show that the species are distinct. The life history is of interest since both the cercaria and adult are monostomes, whereas closely related species are distomatous.

Gonad stimulating hormones from the anterior pituitary gland and other sources. W. R. BRENEMAN, Indiana University.—Three major sources of gonadotropins have been recognized in vertebrates, (1) implants of the anterior pituitary gland or extracts of this gland, (2) urinary extracts and (3) blood serum. Preparations of the pituitary gland have been referred to generally as the A. P. (anterior pituitary) substances and those from other sources as the A. P. L. (anterior pituitary-like) hormones. The protein nature of all these gonadotropins has been well established but many complicating factors still prevent their exact chemical and biological determination. This is illustrated by the fact that only one of these has been prepared in pure form, by differences in the physical and chemical nature of substances which have been shown to have the same physiological action, by physiological differences between extracted hormones and the secreted ones and, finally, by the incomplete understanding of pituitary changes during the life cycle of any organism.

The concept of the anterior pituitary as the "master gland" or as a producer of "trigger hormones" which stimulate the release of "target hormones" from other sources has been an over-simplification. The anterior pituitary is influenced by gonad, thyroid and adrenal hormones as well as by variations in light and nutrition. Illustrations in the chick demonstrate that there is a very pronounced sex difference in

pituitary weights; that the pituitary of the cockerel has greater gonad-stimulating potency than that of the pullet and that limitation of diet, unilateral castration, complete castration and hormone injection greatly modify pituitary growth and secretory activity. The experimental data from mammal and bird, when correlated with a detailed study of normal pituitary function, promises to clarify some of the discrepancies which exist at present.

Notes on the life history of *Neoechinorhynchus emydis* (Leidy), an acanthocephalan parasite of turtles. WILLIAM B. HOPP, Purdue University.—Specimens of *Graptemys geographica* (Le Sueur) from the Tippecanoe River have been found to harbor adults of *Neoechinorhynchus emydis* (Leidy), an acanthocephalan parasite reported from several species of North American turtles. Although experimental determination of the life cycle is not yet completed, juvenile forms which occur in the foot of the snail, *Campeloma sp.*, are believed to be young stages of *N. emydis*. Immature worms have been recovered from the intestine of painted turtles *Chrysemys bellii marginata* (Agassiz), which had been fed infected snails after examination of several of a lot collected from a pond proved to be negative for acanthocephala. Experimental attempts to infect snails by feeding eggs of *N. emydis* are in progress. To the writer's knowledge, a molluscan intermediate host has not been reported to occur in the life cycle of any other thorny headed worm. The present study indicates that, unlike other groups of parasites, closely related species of acanthocephala may differ greatly in the type of intermediate host utilized in the life cycle.

Notes on a giant cystocercous cercaria and its life history. PHILIP G. SEITNER, Purdue University.—Specimens of *Pleurocera acuta* Rafinesque and *Goniobasis livescens* (Menke), collected from the Eel River near North Manchester, have been found to harbor a new cystocercous cercaria which is remarkable for its size and the close similarity of its adult stage to *Proterometra macrostoma*, a species having a very different larval form. The cercariae may attain a length of over 19 mm., which may be as long as the shell of the snail host. Unlike other azygiid larvae, the tail furcae are weakly developed and not used in swimming. Movements are not vigorous but consist of flexing the tail stem near the middle, alternately left and right as a rule: thus the larva may be driven slowly forward or backward. Seldom, however, does it rise from the bottom of the dish. The cercaria is progenetic and the uterus may contain over 50 eggs, many of which are in an advanced stage of development. The usual criteria for distinguishing species of adult trematodes reveal no significant differences between the present species and *Proterometra macrostoma*, yet, because of differences in their larvae, the species must be regarded as distinct. This is in contrast to the usual observation that cercariae are more alike than are their adult stages.

Natural history of Indiana, a 16 mm. kodachrome motion picture illustrating the social behavior of animals. HOWARD H. VOGEL, JR.,

Wabash College.—This motion picture is designed to illustrate the types of social behavior shown by some of our common Indiana birds and mammals. A series of pictures of nesting mourning doves and of an experimental flock of chickens are used to indicate some of the important types of avian social behavior. Allelomimetic behavior (mutual imitation) is seen clearly in the young chicks. Epimeletic behavior (care of the young by parents) and et-epimeletic behavior (young calling to parents), fighting, and several kinds of defensive reactions are photographed in these birds.

A short scene shows unusual protective behavior by a wounded woodcock; the camera follows hunting dogs retrieving bobwhite quail.

The behavior of five Indiana mammals, the opossum, woodchuck, chipmunk, deer mouse, and rabbit, are photographed. There are also pictures of a captive great horned owl running on the ground in an attempt to escape; a large black snake, basking in the sun; and a frog, sitting among the lily pads of a pond.

A group of bettles on a fence post show social aggregation. Nearby a praying mantis shows its method of securing food.

The object of this film is twofold: first, to illustrate graphically osme of our common Indiana animals, and second, to show their various types of social behavior.

Demonstration of Urinary Gonadotropins in Normal Men, Using the Chick as a Test Animal.

K. K. Liaptcheff and W. R. Breneman, Waterman Institute and Department of Zoology[1]

Extensive assays have been made of pregnancy urine and similar studies have been reported of normal or menopausal female urine, but comparable studies of male urine in normal or pathological conditions have been limited. It is the purpose of this paper to report some analyses of gonadotropic potency of normal male urine as measured by the response of the gonads in chicks.

Methods for quantitative concentration of urinary gonadotropic substances have attracted considerable attention in the past several years and particular interest has been attached to the application of these methods to the urine of normal individuals which, because it contains very small amounts of the active material, must be concentrated into small volumes of non-toxic extract in order to be suitable for assay. Although most assays have been made with pregnancy urine, some of these methods can be applied successfully in extraction of gonadotropins from normal male urine.

An alcohol precipitation method was introduced by Zondek (1928) which according to some investigators appeared to be the easiest and most nearly quantitative, but required additional purification procedure when applied to normal urine. Katzman and Doisy (1934) proposed a benzoic acid method of obtaining gonadotropic extracts from pregnancy urine. This was found to be too toxic for assay, when used in large amounts. Hellbaum, Fevold, and Hisaw (1935) introduced a tannic acid pyridine method, which is claimed to be quantitative since the purified extracts in comparable dose are as active as the original urine. Levin (1941) reported the first precipitation of gonadotropins from normal male urine by a new tannic acid method. The size of the yields, compared to those obtained by the other methods, suggested that tannic acid is a suitable and effective precipitant for the gonadotropins of normal urine. This method was claimed to yield the least toxic preparations. Evans and Gobraman (1942) described a modified alcoholic precipitation method for preparation of gonadotropic concentrates from normal male urine which is claimed to be superior to all other methods as to its non-toxicity and its quantitative concentration.

In connection with our work it is of interest to note that very little work has been done on assaying of urine gonadotropic extracts in birds. Several investigators have performed such experiments by using pregnancy urine extracts. Riddle (1931) showed failure of pregnancy urine extracts, prepared by the Zondek method, on testes of immature pigeon or

[1] Waterman Institute No. 96 and Zoology No. 350.

ring-dove as a test object for qualitative and quantitative measurement of urine gonadotropins, regardless of the dose level employed. Schockaert (1934) injected extracts from pregnancy urine, prepared by the Zondek method, to chicks, found that these extracts were inactive in these forms in regard to the endocrine and the gametogenic functions. No increase in growth of the testes or the comb was observed.

Materials and Methods

Pooled samples of urine of the male staff of the department and college men were precipitated in lots of 18-21 liters. For extraction of the gonadotropins from the urine, Fevold's method was used at first, but later it was replaced by Levin's method which was found to be easier and faster.

The gonadotropic potency of the normal male urine was determined by assaying the extract in chicks and observing its effect on chick testicular weight. The method employed was that described by Byerly and Burrows (1938) according to which the chicks were kept in shipping boxes without food or water during the 96-hour assay period. The chicks were divided into different series, each of which received different concentrations of the extract. The concentrations ran from 100-800 cc. equivalents of urine per chick. The final extract was dissolved in water of such volume that 1 cc. of the extract was equivalent to 1000 cc. of urine. All injections were made subcutaneously and each chick received six injections of .25 cc. each at intervals of 12 hours. The control chicks were injected with water. At the fifth day, the chicks were killed by breaking the neck, testes were removed, weighed, and placed immediately into Helly's modification of Zenker's fixative. The tissues were embedded, sectioned in the customary manner, and then stained with Harris hematoxylin and eosin.

The estimation of the gonadotropic potency was made in terms of "chick units" since rarely more than ten birds were used in each series, 25 per cent increase of gonad weight above the control average was considered to constitute a chick unit. In this paper only standard errors for percentage gonad weights are presented, because according to Breneman (1945), the standard errors for percent body weight do not differ significantly from those for the gonad weight. In all the experiments, only single comb White Leghorn cockerels received 12 hours after hatching were used.

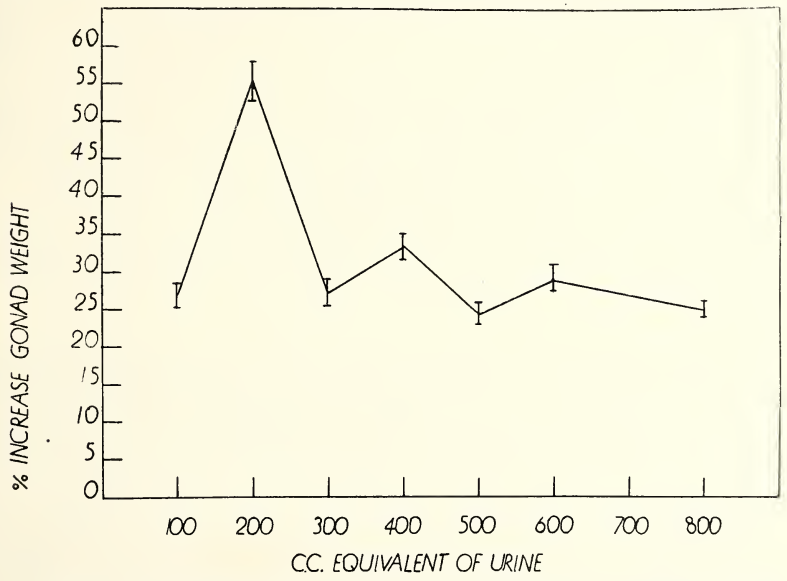
Results and Discussion

The consistent increase in gonad weights of the injected chicks over the controls, which was observed throughout the period of experimentation, indicates that there are some gonadotropic substances present in the normal male urine and that the chick gonads are very sensitive to such concentrations of gonadotropins.

Graphs I and II illustrate the results obtained with extracts prepared according to Fevold's and Levin's methods respectively for the

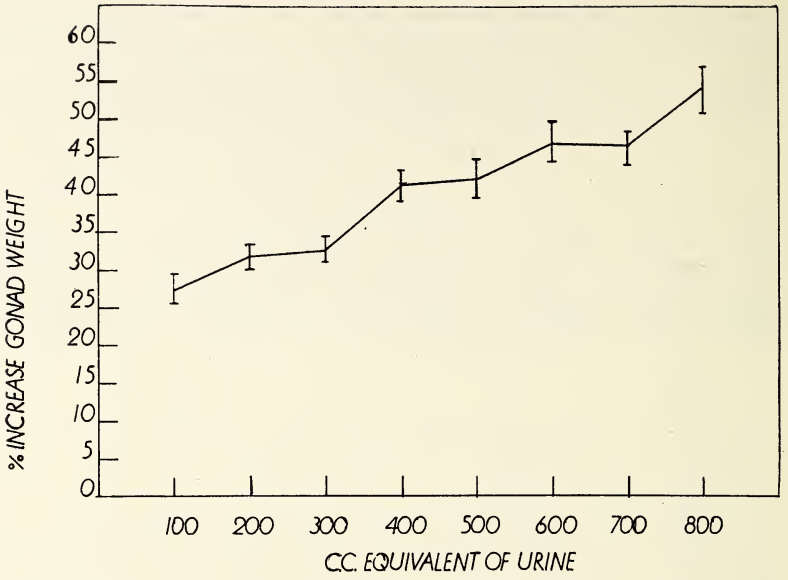
extraction of gonadotropins from pregnancy and normal male urines. An analysis of these graphs demonstrates a striking difference in the gonad weights, following injection of extracts prepared by the first method (Fevold's) when compared with those which resulted from the administration of extracts using the second method (Levin's).

The extracts prepared by the Fevold's method exceeded slightly the potency of those prepared by the Levin's method at low dosage level (note 200 cc. equivalents of urine per chick), but it was toxic when used at higher dosages than 600 cc., because most of the birds injected with such dosage began to die after the second injection. The curve representing the increase of the gonad weight of injected chicks over controls, after reaching a peak at 200 cc., abruptly fell to the level



Graph I. Gonadotropic potency of extracts prepared by the Fevold's method. Vertical lines represent standard errors. A total of 200 animals were used to determine the curve.

of the lowest dosage, and rose again in two peaks each smaller than the first one. The greatest increase of the gonad weights was obtained with extracts of 200 cc. (equal to 2.22 chick units) and the smallest with extracts of 500 cc. (equal to .93 chick units). The irregularity of this curve can probably be explained by the toxicity of the extracts which may be due to the incomplete purification of the final extract, or by the presence of some toxic or inert substances the toxicity of which could be noticed only at high dosage levels. The toxicity of the extract and the irregularity of the results obtained by this method necessitated the application of another method which could give better results.



Graph II. Gonadotropic potency of extracts prepared by the Levin's method. Vertical lines represent standard errors. A total of 500 animals were used to determine the curve.

Levin's method was found to be less toxic than Fevold's even when given in concentrations as high as 800 cc. It was also found to be simpler and required very little time for extraction. In the results obtained by extracts of this method, a correlation was shown between the increase in the gonad weight and the increase in concentration of the extract. There was a general tendency for progressive increase in a straight line with a little deviation due to the fact that results with concentrations of 300 and 700 cc. were a little below, and with concentrations of 400 cc. a little above this line. The increase in gonad weights with this extract ranged from 1.08 chick units for the lowest dosage level (100 cc.) to 2.17 chick units for the highest dosage levels (800 cc.).

Histological data failed to demonstrate any significant increase in the size of the tubules or relative increase of the interstitial tissue. There are some indications of formation of lumina and increase in the total diameter of the gonads of the injected chicks. In the control chicks, a general retrogradation of the gonads was observed which is probably due to the process of inanition used during the period of experimentation.

From the above data we may conclude that in the normal male urine the concentration of the gonadotropic substances is very low. Although it is sufficient to keep the gonads of the injected chicks from retrogradation, it is not sufficient to stimulate them.

Summary

Assays of gonadotropic substances of normal male urine were made using the 96-hour chick test. The gonadotropic potency was determined in terms of chick units, using 25 per cent increase of gonad weight over controls as a chick unit. Two different methods were used for extraction of the gonadotropins from the urine, Fevold's and Levin's, but the first extract was found to be toxic when given in high dosages.

The preparations obtained by the Levin method were less toxic than Fevold's and showed a correlation between the increase in the gonad weight and increase in the concentration of the extract. The potency of extracts prepared by the Fevold's method ranged from .93 chick units (for concentration of 500 cc.) to 2.22 chick units (for concentration of 200 cc.). For Levin's method extracts the potency ranged from 1.08 chick units (or concentrations of 100 cc.) to 2.17 chick units (for concentrations of 800 cc.).

Histological data failed to demonstrate any significant increase in size of tubules or relative increase of interstitial tissues. There was some indication of formation of lumina and increase in total diameter of the gonads of the injected chick.

These data indicate that there are some gonadotropic substances present in the normal male urine which will affect the avian testes.

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Cellular Constituents and Chemistry of the Hamster's Blood

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The contacts with tropical diseases which our armed forces have had during World War II have markedly increased the interest in this class of ailments. Beyond the investigations in bird and monkey malaria and the work on amebic dysentery in the monkey, very little has been done in this field, because there have been no suitable laboratory animals to act as hosts. The comparatively recent work of Adler (1) and Soong and Anderson (2) on the transmission of leishmaniasis to the hamster has made that animal very important in experimental therapy.

Considerable work has been done on the hamster, particularly in the field of infectious diseases. Although blood cell studies have been conducted (3, 4), blood chemistry has not been attempted to a great extent. Since some knowledge of these factors is essential in the use of an animal for the investigation of the effect of drugs, we found it necessary to carry out certain experiments. Our work on the response of the hamster to drugs appears elsewhere (5).

The purpose of the present study was to establish some blood chemistry standards and to investigate some of the hematological elements concerned with the physiology of the hamster. Throughout our experiments, the Syrian or Golden Hamster, *Cricetus auratus*, was used.

The report on the hematology of the hamster by Stewart, Florio, and Mugrage (3) made it unnecessary for us to do a complete blood study. We did, however, make total erythrocyte and leucocyte counts, hemoglobin determinations, and differential counts (Table I). In addition, the more common blood chemistry tests, including those for uric acid, urea, creatinine, non-protein nitrogen, calcium, inorganic phosphorus, and prothrombin, were applied (Tables II, III, IV, and V).

Our animals were obtained from a dealer and allowed to become acclimated to our air-conditioned quarters for about a week. Their food consisted of a commercial diet, "Purina Laboratory Chow," with a liberal addition of kale. All hamsters were between 2 and 5 months old.

The hamster tends to bite anyone who handles it. It is necessary, therefore, to hold it with leather gloves. In order to draw blood for cell counting, the animal is placed in a telescope-like holder. The right hind leg is allowed to protrude from a slot in the side of the holder. A needle prick through the shaved skin into a superficial vein of the exposed leg will permit a sufficient blood flow. This procedure, however, does not allow withdrawal of enough blood for chemical analysis. It is necessary, therefore, to anesthetize the hamster and make a cardiac puncture.

The total erythrocyte and leucocyte counts are the average of duplicate counts on the same group of animals. The blood was col-

Table I. Blood Counts on the Hamster

Animal Number	Sex	Weight	Hemoglobin	Erythrocytes	Leucocytes	Neutrophiles	Lymphocytes	Monocytes	Eosinophiles
		gm.	*gm. per 100 cc.*	*millions per cmm.*	*thousands per cmm.*	*per cent*	*per cent*	*per cent*	*per cent*
1	M	84	18.0	8.5	9.2	27	71	2	0
2	M	100	17.1	8.9	9.3	29	65	3	3
3	M	100	19.2	9.7	8.1	27	72	0	1
4	M	90	16.8	9.6	8.5	30	64	4	2
5	M	90	20.0	8.8	8.9	28	69	2	1
6	F	102	21.0	8.9	8.6	29	69	1	1
7	M	88	15.0	7.5	8.8	32	65	3	0
8	M	115	18.0	9.3	9.3	26	70	2	2
9	M	95	17.2	8.2	8.1	25	73	2	0
10	F	110	18.3	9.7	8.3	31	68	1	0
Mean ± Standard Error			18.06 ± 0.54	8.94 ± 0.24	8.69 ± 0.18	28.4 ± 0.7	68.6 ± 0.98	2 ± 0.37	1 ± 0.33

Table II. Representative Blood Chemistry-Organic

Animal Number	Sex	Weight	Uric Acid	Urea	Creatinine	Non-Protein Nitrogen
		gm.	*mg. per 100 cc.*	*mg. per 100 cc.*	*mg. per 100 cc.*	*mg. per 100 cc.*
11	M	109	5.00	12.18	0.93	51.6
12	F	113	4.22	11.90	1.30	46.8
13	M	100	5.64	15.40	1.00	39.7
14	M	97	4.10	20.30	0.87	44.2
15	F	95	4.50	20.65	0.94	47.6
16	F	103	5.06	19.60	0.86	44.4
17	M	96	4.14	13.65	0.91	49.8
18	M	98	4.39	14.70	0.92	48.0
19	M	92	4.05	10.71	0.90	42.1
20	M	105	4.62	13.30	0.95	47.6
Mean ± Standard Error			4.55 ± 0.14	15.34 ± 1.1	0.95 ± 0.04	46.2 ± 1.1

lected and diluted in pipettes certified by the Bureau of Standards, and the counts were made in a Spencer "bright line" counting chamber. For hemoglobin determinations, the blood (0.02 cc.) was diluted with 5 cc. of N/10 hydrochloric acid, and after allowing the mixture to stand for 30 minutes, it was placed in a Fisher Electro-Hemometer. The hemoglobin content was read directly in grams per 100 cc. of blood.

The differential leucocyte count of the hamster agreed with those of other rodents. The chief difference between these findings and those recorded for man is a reversal of the neutrophile and lymphocyte percentage values. In man, the neutrophiles are in the majority; they are the scavenger cells and phagocytize invading organisms. In the rodent, the lymphocytes are greater in number than the neutrophiles.

Hamster blood in amounts up to 2 cc. was collected by cardiac puncture for chemical studies. With the exception of the serum for calcium and inorganic phosphorus determinations, all the blood samples were oxalated immediately. The improved method of Folin (6) was utilized for blood uric acid. The values obtained from 10 animals were 4.05 to 5.62 mg. per 100 cc. of blood, with an average (arithmetic mean) of 4.55 ± 0.14 mg. per 100 cc. This is a little higher than the average range for man. Urea was calculated by the aeration method of Myers, Fine, and Lough (7). These values extended from 10.71 to 20.3 mg. per 100 cc. with an average of 15.34 ± 1.1 mg. per 100 cc. The range of blood creatinine by the method of Folin and Wu (8) was 0.87 to 1.3 mg. per 100 cc. with an average of 0.95 ± 0.04 mg. per 100 cc. Non-protein nitrogen was determined by the micro-Kjeldahl method of Wagner (9). The values for the blood of 10 hamsters ranged from 39.7 to 51.6 mg. per 100 cc. with an average of 46.2 ± 1.1 mg. per 100 cc.

Blood serum calcium studies were made on 30 animals. The amount of blood required by the Tisdall method (10) made it necessary to pool the blood from 10 hamsters for each set of determinations. The result ranged from 11.7 to 13.2 mg. per 100 cc., with an average of 12.47 ± 0.43 mg. per 100 cc. Inorganic phosphorus values, obtained by the procedure of Benedict (11), ranged from 3.85 to 5.81 mg. per 100 cc. with an average of 4.33 ± 0.17 mg. per 100 cc.

Table III. Representative Blood Chemistry-Inorganic

Animal Number	Sex	Weight	Calcium
		gm.	*mg. per 100 cc.*
21	M	114	
22	F	112	
23	F	103	
24	M	95	
25	M	100	11.7
26	M	97	
27	M	94	
28	M	92	
29	F	108	
30	M	103	
31	M	87	
32	M	91	
33	F	100	
34	M	84	
35	F	96	13.2
36	M	92	
37	M	102	
38	M	113	
39	M	94	
40	M	89	
41	M	95	
42	M	98	
43	M	101	
44	F	88	
45	F	105	12.5
46	M	92	
47	M	94	
48	M	111	
49	F	90	
50	M	97	
Mean ± Standard Error			12.47 ± 0.43

Table IV. Representative Blood Chemistry-Inorganic (Continued)

Animal Number	Sex	Weight	Phosphorus
		gm.	*mg. per 100 cc.*
51	F	96	4.10
52	F	102	5.00
53	M	115	3.95
54	M	110	4.15
55	M	117	4.60
56	M	99	5.51
57	M	112	3.95
58	M	111	4.20
59	M	108	4.00
60	M	106	3.85
Mean ± Standard Error			4.33 ± 0.17

The prothrombin time of the hamster blood plasma was recorded in seconds by a modified method of Campbell, Smith, Roberts, and Link (12), in which 'Hemagulen' (Brain Thromboplastic Suspension, Lilly) was used in place of dried rabbit brain suspension. The range for whole plasma was 13 to 15 seconds, with an average of 14 ± 0.16 seconds; and for 12.5 percent plasma (diluted with physiological saline), 20 to 30 seconds with an average of 25.45 ± 0.9 seconds.

Table V. Representative Blood Chemistry-Coagulation

Animal Number	Sex	Weight	Prothrombin Time	
			Whole Plasma	12.5% Plasma
		gm.	*seconds*	*seconds*
61	M	119	13.0	25.5
62	M	104	14.0	29.5
63	M	113	15.0	27.0
64	F	99	14.0	30.0
65	M	105	13.0	20.0
66	M	90	13.5	20.0
67	F	106	14.0	27.0
68	M	117	14.5	21.0
69	M	113	14.0	24.9
70	M	100	15.0	30.0
Mean ± Standard Error			14 ± 0.16	25.45 ± 0.90

Summary

In order to establish a firm basis for pharmacological experimentation on the Syrian hamster, blood cell counts and blood chemical analyses have been carried out. With the exception of creatinine, all values approached or exceeded the upper limits of the standards usually given for man.

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Notes on the Odonata of the Tippecanoe River State Park, Pulaski County, Indiana[1]

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The general dragonfly fauna of Indiana has been thoroughly investigated by several authors, notably E. B. Williamson and B. E. Montgomery. However, nearly complete faunal lists for limited localities and habitats, representing specimens collected over a greater part of the season, are lacking for many areas. Published records of Odonata from Pulaski County (Montgomery 1937, 1941) list only 13 species, indicating that extensive collections from that region are not recorded in the literature. Accordingly, the author, while working with the Lake and Stream Survey of the Indiana Department of Conservation in the Tippecanoe River State Park during the summers of 1943, 1944 and 1945, collected and made observations on the odonate fauna of that locality. Specimens of 48 additional species were collected bringing the total for Pulaski County to 61.

The Tippecanoe River where it flows through the State Park averages, in times of normal water, 100 feet wide and three feet deep, although occasional "holes" at sharp bends may reach depths of nine or ten feet. Since its principal sources are lakes, the river has a relatively constant level and the water is generally quite transparent. Unusually heavy and widespread rainfalls were observed to bring about rises of as much as five feet with a corresponding considerable increase in turbidity. The fall of the river at this point is from 12 to 16 inches per mile and the current speed in midstream about two feet per second. Much of the river bottom is composed of shifting sand, but many of the shallower, swifter sections have gravel and boulder-covered bottoms. In shallow water, on favorable bottom, dense stands of Vallisneria and various species of Potamogeton develop. The river has evolved a series of broad meanders in this part of its course which has resulted in the formation of numerous quiet backwaters where heavy siltation occurs during periods of high water. The piles of drift that have accumulated about the many trees that have fallen into the stream form an important environmental factor. In addition, the matted masses of roots that hang into the water from the steeper banks offer situations suitable for many climbing aquatic invertebrates.

In the general habitat of the river valley, must be included those abandoned river channels containing water that have more or less lost connection with the river itself. During floods these are, of course, continuous with the river, but for a greater part of the summer they are completely isolated from the river and support independent fauna

[1] Contribution No. 351 from the Department of Zoology, Indiana University.

and flora. One such lagoon or bayou is to be found at Group Camp 1. Locally known as the Hoch Bayou, this body of water is a typical oxbow some 1300 feet long and 75 feet wide with a maximum depth of about five feet. Being well shaded in its shallower portions it supports only small stands of Nuphar and Nymphaea, but during favorable seasons luxuriant growths of Elodea and Cabomba develop. Unless removed by occasional high water, blankets of floating filamentous algae and Lemna form a dense surface mat.

Certain species of Odonata may be pointed out at being characteristic of these two environments. Among the zygopterans the following species might be listed as being typical of the river proper: *Calopteryx maculata, Hetaerina americana, Argia apicalis, A. sedula, A. moesta, A. tibialis,* and *Enallagma exsulans.* Of the anisopterans, the gomphines dominate the river. Those most commonly seen included: *Progomphus obscurus, Hagenius brevistylus, Gomphus lineatifrons, G. fraternus, G. quadricolor, G. vastus, Stylurus amincola, S. spiniceps,* and *Dromogomphus spinosus.* Three aeschinines were of frequent occurrence on the river: *Boyeria vinosa, Basiaeschna janata,* and *Nasiaeschna pentacantha. Macromia illinoiensis* was the only libellulid commonly observed on the open river, but other species, among them *Holotania luctuosa* and *Neotetrum pulchellum,* were always to be found about quiet backwaters. *Sympetrum rubicundulum* was seen abundantly in woods and fields adjacent to the river; other libellulines occurred similarly, but not in great numbers.

The Hoch Bayou at Group Camp 1 supported a typical pond fauna including: *Enallagma geminatum, E. signatum, Ischnura posita, I. verticalis, Anax junius, Tetragoneuria cynosura, Holotania luctuosa, Neotetrum pulchellum, Plathemis lydia, Perithemis tenera, Erythemis simplicicollis,* and *Pachhydiplax longipennis.*

The author is greatly indebted to Dr. B. E. Montgomery of Purdue University since he identified or verified some specimens of each species recorded. Mr. Paul Thompson who worked with the author on the Lake and Stream Survey in 1945 collected many of the specimens listed below, three of which were new to the locality, having never been taken by the author. The periods over which collections and observations were made extended from July 25 to August 18, 1943; from April 26 to August 12, 1944; and from May 7 to August 26, 1945. Collecting was done along the river in the vicinity of Group Camp 1 and for about two miles downstream in all three summers, also along about a half mile of river just north of the Shelter House at the Park Picnic Area in 1945. Collections were made about the Hoch Bayou in all three summers and about some of the bayous in the vicinity of the Shelter House in 1945. A total of 691 specimens referable to 59 species are listed. Most of these have been retained by the author; however, some are now in the collection of Dr. B. E. Montgomery, while others of the commoner species which were damaged or lacking in data have been discarded. Records of the discarded material have been included in the list in order to give a more complete picture of seasonal distribution.

Annotated List of Species

1. *Calopteryx aequabile* Say. 1♂, vii.4.44 (sight record).

The single specimen of this species was seen at a weedy riffle on the river. Identification was positive since the specimen was nearly taken by hand.

2. *C. maculata* (Beauvois). 1♀, vii.2.45; 1♂, vii.27.43; 2♂ 3♀, vii.28.43; 1♂, viii.2.43; 1♀, viii.12.43.

First observed in the middle of June, this species was quite abundant by early July and remained so until observations ceased in late August. Exuviae were found on trees as high as six feet above the river and an equal distance back from the bank. Adults were most frequently observed about grass or bushes along the water's edge. Oviposition occurred on floating masses of twigs and stems.

3. *Hetaerina americana* (Fabricius). 1♂ (teneral), vi.27.45; 1♂ (teneral) 2♀, vi. 28.45; 4♂ (3 teneral) 2♀, vii.2.45; 1♂ (teneral) 1♀, vii.3.45; 4♂ 4♀, vii.5.44; 1♂ 3♀, vii.7.44; 1♀, vii.11.45; 1♂, vii.17.45; 1♂ (teneral) 1♀, vii.19.45; 3♂ 1♀, vii.27.43; 1♂ (teneral) 3♀, vii.28.43; 1♂, vii.28.44; 1♂ (teneral) 1♀, vii.29.43; 1♂ 1♀, vii.30.43; 1♀, vii.31.43; 1♂ 1♀, viii.1.43; 2♂ (1 teneral) 2♀, viii.10.43.

A common species, first observed in numbers in late June. The adults of both sexes congregate about willows that hang over into fast water, about brush that emerges from fast water, and in grass at the very edge of the water.

4. *Lestes disjunctus* Selys. 1♂ 1♀, vii.28.44.

5. *L. forcipatus* Rambur. 2♀, vii.28.43.

6. *L. inaequalis* Walsh. 1♂ 1♀, vii.11.45; 1♀, vii.28.43.

7. *L. rectangularis* Say. 1♂, vii.2.45; 1♂ 1♀, vii.8.45; 7♂, vii.10.45; 2♂, 5♀, vii.11.45; 1♂, vii.13.44; 1♀, vii.19.45; 1♂, vii.20.45; 1♂, vii.28.45.

8. *L. dryas* Kirby. 1♀, vii.11.45.

9. *L. unguiculatus* Hagen. 1♀, vii.7.44; 1♀, vii.19.45; 8♂ 6♀, vii.27.43; 6♂, viii.23.45.

The six species of *Lestes* recorded above were all taken in grass or bushes within a few hundred feet of the river or one of the bayous. *L. unguiculatus* and *L. rectangularis* were the only species that were at all common. The latter seemed to prefer the shade of wooded areas along the river while *L. unguiculatus* was more often seen in clearings.

10. *Argia apicalis* (Say). 1♀, vii.25.43; 3♂, vii.26.45; 6♂ 2♀, vii. 28.44; 2♂, 4♀, vii.29.43; 1♀, vii.30.43; 1♂, viii.10.43; 3♂ 1♀, viii.26.45.

The habits of this species are similar to those of the much more abundant *A. tibialis*. It did not appear commonly, until late July and maintained only a moderate abundance until observations ceased in late August.

11. *A. moesta* (Hagen). 1♂, vii.26.45; 8♂, vii.28 to viii.5.44; 1♀, vii.29.43; 2♂, undated 1944.

This *Argia* differs in habits from the other common species recorded. It was most often encountered flying along a few inches above the water in midstream and showed little tendency to be gregarious. While of moderate abundance, it was relatively difficult to capture.

12. *A. sedula* (Hagen). 1♀ (teneral), vii.20.45; 2♂, vii.26.43; 2♂, vii.27.43; 3♂ 7♀, vii.27 to viii.3.44; 1♀, vii.29.43; 1♂, viii.12.43; 2♂ 1♀, viii.26.45.

The habits of *A. sedula* are similar to those of *A. apicalis*. It was found over the same seasonal range as that species but somewhat less commonly.

13. *A. tibialis* (Rambur). 4♂ (3 teneral), vi.20.45; 1♂ 1♀, vi.23.45; 4♂ 3♀, vi.26.45; 1♂ 1♀, vi.28.45; 3♀, vii.2.45; 3♂ 4♀, vii.3.45; 5♂ 1♀, vii.6.44; 3♂ 1♀, vii.8.45; 1♂ 2♀, vii.11.45; 2♂ 2♀, vii.19.45; 2♂, vii.27.43; 9♂ 11♀, vii.27 to viii.3.44; 2♂ 2♀, vii.28.43; 1♂, viii.2.43; 1♂, viii.10.43; 1♂, viii.26.45.

A. tibialis was the first species of this genus to emerge, appearing shortly after mid-June and becoming exceedingly abundant by the first week in July. Large groups of mating and ovipositing pairs were observed throughout July and into August. These aggregations were always found where quantities of floating debris had been trapped within drifts, usually in moderate current.

14. *A. violacea* (Hagen). 1♂, vii.31.43.

Although watched for rather carefully, this species was taken only once and must be considered rare for this locality.

15. *Enallagma antennatum* (Say). 1♀, vii.10.45.

The single specimen recorded was collected at the Picnic Area by Paul Thompson.

16. *E. exsulans* (Hagen). 1♂, 1♀, vi.23.45; 1♂, vi.27.45; 1♂ (teneral), vii.1.45; 2♂ 1♀, vii.2.45; 1♂, vii.7.44; 5♂ 1♀, vii.11.45; 1♂, vii.11.44; 2♂ 2♀, vii.13.44; 3♀, vii.19.45; 1♂, vii.28.43; 5♂ 3♀, vii.28 to viii.5.44; 1♂, viii.1.43.

Quite abundant both on the river and the Hoch Bayou throughout a rather long flying season from late June through August

17. *E. geminatum* Kellicott. 3♂ 1♀, vii.28.43.

The specimens recorded were taken on the Hoch Bayou where this species was not common.

18. *E. hageni* (Walsh). 1♂, vii.10.45; 1♂, undated 1945.

One specimen of this species was collected along one of the bayous near the Shelter House by Paul Thompson; the undated one by the author at the Hoch Bayou.

19. *E. signatum* (Hagen). 2♂ 2♀, vii.28.44; 1♀, viii.12.43.

A fairly common species on the Hoch Bayou and occasionally seen over quiet backwaters of the river.

20. *Nehalennia irene* Hagen. 1♀, vii.11.45.

Apparently quite scare. A single specimen collected in 1944 has been lost. The one recorded above was caught in grass along the river.

21. *Chromagrion conditum* (Hagen). 2♂, v.28.44.

Both of the above specimens were collected by I. Owen Foster Jr. along one of the ditches which flank the road leading to Group Camp 1. Although probably not a part of the fauna of the river or its flood plain, this species is here included because of the scarcity of Indiana records of it.

22. *Ischnura posita* (Hagen). 2♂, v.26.44; 1♂ 1♀ (1♀ teneral), v.26.45; 2♂, .27.45; 1♂ 1♀, vii.28.44; 1♂, vii.29.43.

A rather uncommon species, collected in grass along the river and about the Hoch Bayou.

23. *I. verticalis* (Say). 1♀, v.24.44; 3♂ 3♀, v.25.44; 1♀, v.26.44; 1♂ (teneral), v.26.45; 1♂ 1♀ (both teneral), v.27.45; 1♀, vii.11.44; 1♂, vii.11.45; 1♂ 1♀, vii.26.43; 1♂ 1♀ (♀ teneral), vii.28.43; 4♂ 3♀, vii.28.44; 3♂ 2♀, vii.29.43.

A very abundant species along the river banks and around all bayous visited.

24. *Progomphus obscurus* (Rambur). 2♀ (tenerals), vii.1.45; 2♀, vii.2.45; 1♂ vii.3.45; 1♂ 1♀, vii.5.44; 1♀, vii.18.44; 1♂, vii.18.45; 1♂, vii.20.44.

This midsummer gomphine was moderately common It was often observed cruising up and down the river a few inches above the water or resting on sand bars.

25. *Hagenius brevistylus* Selys. 1♂ (emerging) 1♀, vi.21.45; 1♀, vi.23.45; 1♂, vi.27.45; 1♂, vii.1.45; 1♀, vii.3.45; 1♀, vii.6.44; 1♀, vii.8.45; 1♂, vii.11.44; 1♀, vii.11.45; 1♂, vii.18.45; 1♂, vii.27.43; 1♂, viii.2.43; 1♂, viii.6.43; 1♂, viii.9.43; 2♂, viii.10.43; 1♂, viii.12.43.

Hagenius was one of the few gomphines which could be seen almost every day all summer long. Despite its size and flying ability it was not very difficult to take, partly because of its fearlessness and partly because of its habit of flying a "beat" with definite perches along it. A female of this species was observed ovipositing late in the afternoon of July 14, 1945. She faced a bank of the stream which rose abruptly about four feet from the water. The bank was hung with a mass of roots and rootlets of a nearby silver maple. She would hover for an instant a few feet from the bank and about a foot above the water, then flying toward the bank and dropping, she would dip her abdomen at the water's edge, rise a few feet and return to her original position

without turning around. This action was repeated several dozen times without interruption.

26. *Ophiogomphus rupinsulensis* (Walsh). 1♀ (emerging), vi.1.45; 1♂ (teneral), vi.9.45.

The emerging female was taken on a root a few inches above the water about nine a. m. The teneral male was floating down midstream, helpless. Besides these recorded specimens, one adult was seen in mid-June of 1945. A rather rare species for the locality.

27. *Erpetogomphus designatus* Hagen. 1♀ (emerging), vii.11.45.

The single specimen taken was found by Paul Thompson at his camp near the Shelter House. The mature nymph was ascending some roots along the river bank. Only one additional specimen was seen in late July hence this too must be considered a rare species.

28. *Gomphus lineatifrons* Calvert. 1♂, vi.4.44; 1♂, vi.19.45; 1♀, vi.21.45; 3♂ 1♀, vii.1.45; 3♀, vii.2.45; 1♂ 2♀, vii.4.45; 1♂ 1♀, vii.5.45; 1♀, vii.6.44; 1♂, undated 1944.

A very common member of the genus *Gomphus* from early June to mid-July, seen occasionally over the Hoch Bayou. A female captured July 2, 1945, was in the act of eating a specimen of *Progomphus obscurus*.

29. *G. fraternus* (Say). 2♂ (1 teneral) 1♀ (teneral), v. 28.44; 1♂, vi.1.44; 1♂ (teneral), vi.10.45; 1♂, vi.12.45; 2♀ (tenerals), vi.14.45; 1♂, (teneral), vi.15.45; 2♂ (teneral), vi.18.45; 1♀, vi.20.44; 1♀, vi.21.45; 1♂, vi.22.44; 1♂, vi.22.45; 1♂ 1♀, vii.1.45; 1♀, vii.3.45; 1♂, vii.8.45; 1♂, vii.25.45; 1♀, vii.30.44; 1♂, undated 1944.

The commonest gomphine observed, with a flight season extending from late May through late July. A peak of abundance was reached in the first week of July when many copulating pairs were seen in a meadow by the river.

30. *G. lividus* Selys. 1♂, v.24.44; 1♂ (teneral), v.27.45; 2♂ 1♀, v.28.44.

A rather scarce species.

31. *G. quadricolor* Walsh. 3♂ (tenerals), v.24.44; 1♀, v.28.44; 1♂, vi.244; 1♂ (teneral), vi.2.45; 1♀, vi.3.44; 2♂, 1♀, vi.4.44; 1♂ 3♀ (all tenerals), vi.6.45; 1♂, vi.20.44; 2♂ 1♀, vi.21.44; 1♀, 22.44; 1♀, vi.28.45; 1♀, vii.1.45; 1♀, vii.3.45; 1♀, vii.4.45; 1♀, vii.6.45.

Very common in late May and early June.

32. *G. vastus* Walsh. 1♀, vii.1.45; 1♀, vii.2.45; 1♀, vii.3.45; 1♀, vii.4.45; 1♀, vii.6.44; 1♀ vii.8.45.

Not a very common species with a rather limited seasonal range.

33. *G. ventricosus* Walsh. 1♀ (teneral), vi.6.45; 1♀ (teneral), vi. 8.45; 1♀, vi.27.45; 1♀, vii.13.45.

A rather scarce species, but apparently one with a rather long seasonal range.

34. *Stylurus amnicola* (Walsh). 1♂, vi.27.45; 1♂ (teneral), vi. 28.45; 1♂, vi.30.45; 3♂ 3♀, vii.2.45; 1♂ 2♀, vii.3.45; 3♀ (tenerals), vii.5.45; 1♀, vii.6.45; 1♂ 1♀, vii.9.45; 2♂, vii.10.45; 1♂, vii.13.45.

Although first recorded in the state from Knox County in 1924 (Montgomery 1925) and taken in but two additional localities (Tippecanoecanoe County, Montgomery 1937 and Warren County, Montgomery 1941) since that time, this species was one of the most abundant gomphines encountered on the river.

35. *S. spiniceps* (Walsh). 1♂ (emerging) 2♀ (1 emerging, 1 teneral), vii.23.45; 1♂ (teneral), vii.25.45; 1♀ (teneral), vii.no date.45; 1♂, viii.no date.44; 1♀, viii.27.45.

This gomphine was the last to appear in the summer and was never very common.

36. *Dromogomphus spinosus* Selys. 1♂ 1♀ (both teneral), vi.21.45; 1♂ (teneral), vi.23.45; 1♂ (teneral), vi.27.45; 1♂ (teneral), vi.28.45; 2♂ (1 teneral), vii.3.45; 1♀, vii.5.45; 1♂, vii.6.44; 1♂, vii.7.44; 1♂, vii.9.44; 1♂, vii.20.44; 1♀, vii.22.45; 1♀ (teneral), vii.27.45; 3♂, viii. 10.43; 2♂, viii.12.43; 1♀, viii.23.45.

A very common species first observed in late June and still flying when observations ended in late August.

37. *Boyeria vinosa* (Say). 1♂, vii.19.45; 1♂, vii.29.44; 1♀, viii. 16.45; sight record, ix.20.45.

This species is much more common than the above records show. It emerges in late July and flies at least until late September. All individuals observed were flying "beats" a foot or two above the water along the edges of the river, usually in late afternoon or evening.

38. *Basiaeschna janata* (Say). 1♀ (teneral), v.25.44; 1♂ (teneral), v.26.44; 1♀, v.28.44; 1♂, vi.1.45; 2♂, vi.2.44; 1♂ (teneral), vi.7.45; 1♂, vi.10.45; 1♂, vi.29.45.

A fairly common species over the river and the Hoch Bayou, but seldom seen after July 1.

39. *Anax junius* (Drury). 1♀, vi.19.45; 1♀, vi.20.45; sight record, ix.20.45.

Although seen frequently over the Hoch Bayou and fields adjacent to the river, this species was taken only once on the river proper. The female collected June 20, 1945, was taken on a grapevine a few inches above swift water.

40. *Nasiaeschna pentacantha* (Rambur). 2♂ 1♀, vi.2.44; 1♂ 3♀, vi.3.44; 1♂, vi.19.45; 1♂ 2♀, vi.27.45; 1♀, vii.2.45; 1♀, vii.26.45.

This species followed *Basiaeschna* in emergence by a week or ten days and like that species was seen hawking over both the river and bayou. It was fairly common in both habitats in mid-June and a few were seen as late as mid-August. The female captured July 2, 1945, was eating a specimen of *Gomphus vastus*.

41. *Macromia illinoiensis* Walsh. 1♀ (emerging), vi.10.45; 1♀ (emerging), vi.14.45; 1♂ 1♀ (both teneral), vi.21.45; 1♀, vi.29.45; 1♀ (emerging), vii.2.45; 1♀ (teneral), vii.5.44; 1♀, viii.1.45; 1♂, viii.14.45; 1♀, viii.17.45.

Common from mid-June through August but difficult to capture. Females were frequently seen cruising up and down the river a foot or so above the middle of the stream occasionally dipping their abdomens. Individuals of both sexes often patrolled the paths about the camp, more than a quarter of a mile from the river.

42. *Epicordulia princeps* (Hagen). 1♂, vii.3.45.

A few specimens were seen about the parking lot at the Shelter House by Paul Thompson, but only one was taken. They evidently had come there to hunt from a nearby bayou.

43. *Tetragoneuria c. cynosura* (Say). 1♂ (teneral), v.24.44; 1♂, v.26.44; 4♂ (1 teneral) 1♀, v.28.44.

This libelluline was very common over the Hoch Bayou early in the season, but after mid-June its place in the fauna seemed largely taken by *Pachydiplax longipennis.*

44. *T. c. simulans* Muttkowski. 1♀, v.28.44; 1♂, vi.1.44.

This form was taken flying with typical *T. c. cynosura* over the Hoch Bayou.

45. *Holotania luctuosa* (Burmeister). 1♂ (teneral), vii.2.45; 1♂, vii.5.44; 2♀ (both teneral), vii.7.45; 4♂, vii.27.43; 1♀, viii.1.43; 2♀, viii.2.43.

Very abundant over the bayous and quieter parts of the river.

46. *H. vibrans* (Fabricius). 1♀, viii.9.43.

The single specimen was taken over a meadow adjacent to the river.

47. *Eolibellula semifasciata* (Burmeister). 1♂, vii.30.43.

Taken in the same habitat as the preceeding species.

48. *Neotetrum pulchellum* (Drury). 2♀, v.25.44; 1♂, v.28.44; 1♂ 1♀, vi.3.44; 1♂, vii.4.45; 1♂, vii.5.45; 1♂ 1♀, vii.18.45; 1♂, vii.30.43.

Very common over the bayous and quiet parts of the river.

49. *Plathemis lydia* (Drury). 1♀, v.24.44; 1♂, v.28.44; 1♂ 1♂, vi.1.44; 1♂, vi.22.45; 1♂, vi.27.5; 1♀, vii.2.45; 1♀, vii.5.45; 1♂, vii.11.44; 1♀, viii.1.43; 1♂ ♀, viii.2.43; 1♂ 1♀, viii.5.43.

A very common species on meadows along the river, about the bayous and still parts of the river. Often seen about the paths and buildings at the camp.

50. *Perithemis tenera* (Say). 1♂, vii.28.43; 1♂, vii.28.44; 1♀, vii.29.44; 3♂, vii.31.43.

Not very common over the Hoch Bayou and only occasional over backwaters along the river.

51. *Erythemis simplicicollis* (Say). 1♂, vii.6.44; 1♂, vii.26.43; 1♀, vii.29.44; 1♀, viii.1.43; 1♀, viii.10.43.

Moderately common, particularly over grassy clearings along the river.

52. *Sympetrum ambiguum* (Rambur). 1♀ (teneral), vii.4.45; 1♀, vii.8.45; 1♂, viii.23.45 (W. side).

Rather rare but widespread. The July 4 specimen was taken at the Picnic Area, the July 8 specimen at Group Camp 1, and the August 23 specimen in a swampy area in the northwest corner of the park.

53. *S. obtrusum* (Hagen). 1♂, vi.30.45; 1♂, vii.2.45; 1♀, vii.9.45; 1♀, vii.13.45; 1♂, vii.29.44; 1♀, viii.22.45; 1♂, viii.23.45 (W. side).

Not common, sharing the same habits as *S. rubicundulum.*

54. *S. rubicundulum* (Say). 1♀, vi.21.44; 3♂ 9♀ (tenerals), vi.30.45; 2♂ 5♀ (3 teneral), vii.1.45; 2♂ (teneral) 1♀ (teneral), vii. 2.45; 2♀, vii.4.45; 1♂ 4♀, vii.5.45; 3♂ 2♀, vii.6.44; 3♀, vii.6.45; 2♂ (tenerals) 3♀ (2 tenerals), vii.8.45; 1♂ 2♀ (1 teneral), vii.10.45; 1♂ 4♀ (1 teneral), vii.11.45; 1♂ 5♀, vii.13.45; 2♂ 1♀, vii.19.45; 1♂, vii.26.44; 1♀, vii.28.43; 1♂, vii.28.44; 1♀, vii.29.43; 1♂, vii.29.44; 1♀, vii.30.44; 1♀, viii.no date.44; 9♂ 4♀, viii.23.45 (W. side).

This species was abundant everywhere, often quite far from water; it was most often taken, however, on bushes about the edges of fields and over grassy areas.

In the series collected, two specimens (1♀, vii.8.45 and 1♀, vii.30.44) very definitely fitted the description of the form *assimulatum.* Ten other specimens, six males and four females, showed more or less tendency toward *assimulatum* in their wing coloration.

55. *S. vicinum* (Hagen). 1♀, vii.10.45; 2♀, vii.28.44.

Rare, at least during the periods when collections were made.

56. *Pachydiplax longipennis* (Burmeister). 3♂ 1♀, vi.1.45; 1♂, vi.20.44; 1♂, vi.21.44; 1♀, vi.22.44; 1♀, vii.2.45; 1♀, vii.8.45; 2♀, vii. 26.43; 1♂ (teneral) 2♀, viii.2.43; 2♂, viii.10.43.

Very abundant over the Hoch Bayou from the first of June through August, but only occasional over the quieter parts of the river.

57. *Leucorrhinia intacta* (Hagen). 1♂, v.24.44; 1♂, v.25.44; 1♀, v.26.44; 1♂, v.28.44; 1♂, vi.3.44; 1♀, vi.4.44; 1♀, vii.10.45.

Only of moderate abundance along the quieter waters of the river. About dusk early in the season five or six individuals of this species would gather about the author as he stood by the river. They would dance about a few feet away, but every few moments one would dash up, snatch a mosquito from the flock attracted to the writer, and then return to hover with his fellows.

58. *Tramea carolina* (Linnaeus). 1 ♂, vii.11.45.

This was the only specimen seen, it was hovering above grass at the edge of the river.

59. *T. lacerata* Hagen. 1 ♂, viii.24.45.

Captured flying along a path in Group Camp 1. It was the only specimen seen.

Of the 13 species recorded from the county by Montgomery, two, *Enallagma civile* and *Sympetrum corruptum*, were not taken by the author.

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Phylogenetic Interpretations in the Teaching of Comparative Vertebrate Anatomy

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It has seemed to me that for far too long a time obsolete views pertaining to the phylogeny of vertebrates and their organ-systems have been perpetuated in courses in Comparative Vertebrate Anatomy. The interpretations presented in the usual textbook and laboratory manual are, to a considerable extent, a reflection of those "great generalizations" which have come down to us from the late nineteenth and early twentieth centuries, generalizations which are strongly colored by the principle of recapitulation. Surely it is time to take cognizance of modern evidence and revise our teaching accordingly. This is especially true for the laboratory program wherein the customary series of animal forms, viz. shark, urodele, and mammal, tells an utterly distorted phylogenetic tale. It is the purpose of this discussion to suggest certain important re-interpretations, with an eye particularly to a revision of the laboratory program.

The Ancestry of the Vertebrates

Historically, almost every invertebrate phylum other than the Mollusca has been proposed as a possible progenitor of the chordate line. Except for one group, however, all have been eliminated for one reason or another. That one group favored by present-day opinion is the Echinodermata. Certain similarities in the early development of echinoderms and chordates have long been recognized and it is in terms of embryogeny that their phyletic relationship is customarily established. Long recognized, also, has been the morphological likeness between certain echinoderm larvae and the Tornaria of the balanoglossids. Accordingly, the Echinodermata and Chordata have been derived from a common stem, the hypothetical Dipleurula. From this stock the echinoderms are believed to have evolved as one major stem and the chordates as another. There is a tendency now-a-days, however, to assign the Hemichordata to a separate branch and thus set them off the main line of urochodate-cephalochordate-vertebrate ("Chordonia") evolution (Gislen, 1930). In such a phyletic scheme, it may be questioned whether the hemichordates are to be considered chordates at all, but represent, instead, a phylum of their own.

All such schemes, of course, place strong reliance on embryological data and require the assumption of the general validity of the recapitulation principle. But other facts are available for support of the thesis of origin of the chordates from echinoderm stock. Certain Paleozoic carpioid echinoderms (Abel, 1920) exhibit modifications in

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the direction of bilateral symmetry and some even approach the general patterns of the Ostracoderms, forms whose basic position in the phylogeny of vertebrates is now generally granted. So perhaps the postulation of an ancestral, bilateral Dipleurula is unnecessary; it is not impossible that some radially symmetrical echinoderm or echinoderm-like stock may have inaugurated a new developmental trend toward "chordateness."

More recently, biochemical (Needham et al, 1932) and serological (Wilhelmi, 1942) tests have indicated that extant echinoderms are more closely related to chordates than they are to any other invertebrates.

With the hemichordates set off on a side branch, they cannot be considered as having played a role in the direct ancestry of the vertebrates. Nor are tunicates and Amphioxus, despite their position on the stem "Chordonia," much more illuminating. The tunicates have never been accepted as direct intermediaries between vertebrates and their progenitors. Their specializations are too many and too profound. And Amphioxus, traditionally interpreted as an ancestral type (Willey, 1894), is now-a-days recognized as greatly specialized in some respects and degenerate rather than primitive in others. Leach (1944) is perfectly right when he suggests that teachers of comparative anatomy and vertebrate phylogeny should abandon it as an introductory type form. The likelihood is that Amphioxus, instead of being ancestral to the vertebrates, is a degenerate and greatly specialized derivative of the oldest known vertebrates, the Paleozoic Ostracoderms (Gregory, 1936). The same may be true of the tunicates.

As the situation stands, then, it is generally agreed that the vertebrates trace their origin to an echinoderm-chordate stem. But a great gap exists between the echinoderms and the vertebrates. That gap is filled in neither by extant non-vertebrate chordates nor by fossil forms.* While in the Cambrian deposits the major invertebrate phyla, including echinoderms, are represented, no vertebrates have been found. Yet in the immediately following Ordovocian deposits the relatively well organized first vertebrates, the Ostracoderms, are present. The vertebrates, that is, made an abrupt appearance on the evolutionary scene and for the time being their immediate ancestors remain unknown.

Ammocoetes as an Ancestral Type

As indicated above, Amphioxus is more likely a derivative rather than ancestor of the first vertebrates. On taxonomic grounds alone, then, it should be eliminated as an ancestral type. But since laboratory forms can merely simulate rather than duplicate phylogenetic stages anyhow, this would not be serious provided Amphioxus fulfilled the qualifications of illustrating general chordate anatomy. It has been

* Since this manuscript went to press, there has appeared an important paper (White, E. I., 1946. Geol. Mag., vol. 82, no. 2) describing a new Silurian chordate, Jaymoytius kerwoodi, a fish-like animal without scales and devoid of bone and cartilage. It is believed by its discoverer to represent the kind of organism from which the fishes, Ostracoderms and perhaps even the Cephalochordata could have been derived.

my experience, however, that as an introductory laboratory form its liabilities are greater than its assets. Careful and time-consuming explanation of its specializations must be made if students are to be prevented from drawing erroneous conclusions. Peculiar to Amphioxus and devoid of archetypal significance are: the atrium and reduced coelom, the position and character of the gonads, the elaborately developed pharynx with its great number of gill slits and bars, the degenerate brain, and finally the annelid-like excretory organs. Concerning these last, Goodrich (1902, 1934) has clearly shown they are protonephridia with solenocytes such as occur in certain polychaete annelids. These tubules have nothing in common with vertebrate nephrons and the time has long since come when writers of textbooks should cease referring to them as pronephric tubules.

What form shall replace Amphioxus as an introductory type for laboratory study? The answer is Ammocoetes, the larva of the freshwater lamprey.

It is now fairly generally agreed that of all the known vertebrates, extant and extinct, the oldest and most primitive are the Ostracoderms of Silurian and Devonian times. Of all living vertebrates, the nearest relatives of the Ostracoderms are the Cyclostomata. Modern adult cyclostomes exhibit many degenerative specializations which, as with Amphioxus, make them undesirable as generalized types. But their larval stage lacks most of these specializations and shows a remarkable similarity to the cephalaspid Ostracoderms (Stensio, 1927). As an introductory laboratory form, then, Ammocoetes serves two purposes: (1) it simulates the structure of the Ostracoderms, the basic stock from which, so far as we know, all the other vertebrates have been derived; (2) by way of it the student is introduced to basic structures and relations common to all vertebrates, without the distractions imposed by irrelevant specialization.

The literature on Ammocoetes is abundant and material for laboratory study easily available. Small specimens prepared as transparent wholemounts are especially desirable, supplemented by selected cross-sections and large specimens for gross dissection.

It is in conjunction with the evolutionary history of the various organ-systems of vertebrates that the recapitulation principle has exerted its greatest influence on teaching practices. For some curious reason obsolete interpretations have been maintained in the face of conflicting evidence, particularly in the selection, utilization, and interpretation of laboratory material. It is my purpose to discuss three outstanding instances of obsolete laboratory procedure and to suggest revisions in keeping with modern points of view.

The Skull

The traditional story of the general evolution of the skull runs briefly as follows. The primitive skull is considered to have been cartilaginous in composition. The shark is employed to illustrate this initial stage. Progressively, then, membranous bone encases the chondro-

cranium and the cartilage is replaced by bone. A urodele, Necturus or Cryptobranchus, customarily serves to illustrate an intermediate stage in this conversion, i.e., a cartilage, replacement bone, and membranous bone skull, and the mammalian skull the end point, i.e., the bony skull.

Modern paleontological data, in contrast to classical theory, strongly suggest that the original skeletal material was bone rather than cartilage. The cephalaspid Ostracoderms of late Silurian and early Devonian times not only possessed a superficial armor of bony plates but an ossified internal skeleton as well (Romer, 1942, 1945). It may be argued, of course, that these ancient forms may have been preceded by cartilaginous forebears unknown because cartilage is not fossilized. In rebuttal it may be pointed out that cartilage, then, must have occurred in very remote times for bony tissues featured the scantily known vertebrates of the Ordovician. More significantly, the view of progressive increase in bone and parallel decrease in cartilage which classical theory requires is not substantiated by fact. The later Ostracoderms, for example, show less bone than the older; in its history among the Ostracoderms bone is regressive, not progressive.

An especially clear demonstration of bone reduction is found in the Amphibia. Evans (1944), in reviewing the morphological status of modern Amphibia, has performed an important task in pointing out that modern Amphibia are highly specialized tetrapods and not primitive, a situation long recognized by paleontologists but apparently not so by many zoologists, especially writers of textbooks and laboratory manuals. Speaking of the skull alone, the total number of individual bones is much smaller than that of ancestral Amphibia, e.g., Eryops, and the amount of cartilage much greater. Furthermore, in comparing modern Amphibia and reptiles, Evans has clearly shown that in many respects some of the reptiles, e.g., Iguana, have departed less from the primitive tetrapod condition than have the Amphibia. Special advantage may be taken of this in a manner to be described shortly.

Now it is true that in its embryogeny the skull of a mammal, say, does begin as cartilage which progressively becomes bony by the replacement of cartilage and addition of dermal elements. But classical theory to the contrary, ontogeny by no means recapitulates phylogeny. Rather, the evolutionary history of the skull has been almost the reverse; the primitive condition is one of bony material and numerous separate elements. When the skulls of modern adult vertebrates consist of cartilage in whole or in part, it apparently represents a specialized condition wherein an embryonic adaptation is carried over into adult life (Romer, 1942).

To return to the matter of laboratory teaching, what we have been presenting in the laboratory through the customary shark-urodele-mammal series has not been phylogeny at all but ontogeny imitated by adult types. As indicated once before, any series derived from extant forms alone is necessarily artificial; the chosen forms only imitate, do not duplicate phylogenetic stages. This allows complete freedom of choice. The important thing is to select good imitators and arrange

them in the proper order. I should like to suggest the following series to illustrate the phylogeny of the skull.

1. *The skull of Amia, the bowfin.* It is chosen as the introductory form first because it is representative of a group which is relatively primitive and secondly, and more importantly, the elements of its skull have departed little from the fundamental pattern found in the Crossopterygii. The distinctive feature of the basic fish skull is the presence of an elaborate dermatocranium overlying a brain-enclosing endocranium. Amia is employed to illustrate this dermatocranium alone.

2. *The skull of Squalus, the shark.* A study of the skull of the shark serves two purposes: (a) without reference to its material composition, it exemplifies the basic pattern of the vertebrate endocranium; (b) in contrast to the skull of Amia, it illustrates a condition of degeneracy wherein cartilage is the structural material and a dermatocranium is lacking.

By way of the first two types listed, the fundamental pattern of the vertebrate skull is exemplified; that of the dermatocranium by Amia, the endocranium by Squalus. The history of the skull continues in the tetrapods.

The first tetrapods were amphibians which appeared in Devonian times and were derived from the Crossopterygii. The skulls of these original Amphibia were remarkably similar to those of their piscine ancestors. Modern Amphibia, as previously noted, however, have skeletons in which there are many specialized degenerate features. For that reason, no present-day amphibian will serve to exemplify the primitive tetrapod skull. We turn, instead, to the reptiles.

3. *The skull of the Alligator.* Although the reptiles as a group have been derived from and are thus more recent than the Amphibia, there are extant forms among them which, in respect to skeletal pattern, have departed much less widely from the primitive tetrapod condition than have extant amphibians. This is especially true of certain lizards, for example, Iguana. But since these lizards are not available in quantity, it is more practicable to employ the skull of the alligator. The alligator is somewhat specialized as regards the bones in the roof of the mouth, but otherwise serves as an excellent demonstration of the locations, groupings, and relations of the cranial and jaw bones of tetrapods.

4. *The skull of Necturus.* As pointed out before, modern amphibians although as a group phylogenetically older than the reptiles, are considerably specialized. The skull of the urodele, Necturus, demonstrates this specialization first in the retention of a considerable amount of cartilage within the endocranium and splanchnocranium and secondly, in a reduction in the absolute number of bones as compared with extinct primitive amphibians and many modern reptiles. One purpose, then, of a study of the skull of Necturus is to observe these specializations, i.e., to draw attention to the direction evolution has taken in Amphibia.

A second purpose is served by the hyobranchial apparatus. Although it, too, is somewhat specialized when compared with primitive Amphibia, compared with the reptiles it is much more primitive. It thus illustrates

a condition intermediate to the hyobranchial skeleton of Squalus, on the one hand, and that of reptiles and mammals on the other.

5. *The skull of the cat.* This traditionally employed form illustrates the pattern of the mammalian skull.

The Heart

The customery textbook account of the phylogeny of the heart is another which bears the imprint of the principle of recapitulation. In its embryogeny, the mammalian heart exhibits four chambers, sinus venosus, atrium, ventricle, and conus in that order from posterior to anterior. First the atrium is divided into two auricles and subsequently the ventricle into two. The conus is eliminated as such by being split into pulmonary and systemic trunks; the two sides of the sinus are eliminated by reduction and absorption. These steps are presumed to be paralleled phylogenetically: the heart of a fish corresponds to the primitive four-chamber stage, that of an amphibian presents the divided atrium, and the reptilian heart shows a progressively dividing ventricle. There is evidence to suggest, however, that this was not the phylogenetic order of events; to a degree, in fact, the reverse may have occurrd.

The key to the situation is found in the Crossopterygii, the group of fishes from which the original Amphibia, and thus tetrapods as a group, stemmed. Since, with the exception of one incompletely preserved specimen, these forms are known through fossil material only, direct knowledge of their soft anatomy is lacking But certain inferences can be drawn from a study of the internal anatomy of their nearest living relatives, the Dipnoi, or lungfishes

The heart of a representative lungfish exhibits extensive division into right and left sides The sinus venosus empties into the right side of the atrium which is divided almost completely by a muscular septum into larger right and smaller left auricular chambers. The ventricle, too, is incompletely divided by a conspicuous interventricular septum. A spiral septum divides the conus into two passageways, one of which communicates posteriorly with the left side of the ventricle and anteriorly with the first two aortic arches to the head; the other communicates with the right ventricle and the more posterior aortic arches including the pulmonary. Thus the cavity of the entire heart is incompletely but effectively divided longitudinally into two channels, with the arterial stream on the left driven to the head and the venous stream on the right driven to the lungs.

That the heart of the Crossopterygii was much like this is not unlikely. The presence of internal nares suggests the presence and utilization of an air-bladder like modern Dipnoi, and the rest follows logically. An ultimate answer must be deferred until that fortunate day when additional specimens are brought up from the depths of the South Atlantic.

If it may be granted that the Crossopterygii had some such heart as this, then it is not unlikely that so also did the original Amphibia. Truly enough, modern Amphibia exhibit no such condition, but it must be

remembered that living amphibians are highly specialized and this shows up in the heart as in so many other respects. In none of them is the ventricle divided. In the Anura the atrium is divided into two auricles, the right one receiving the sinus venosus. Leaving the undivided ventricle, blood is directed into separate pulmonary and carotid streams by way of a spiral septum within the conus. That much of the primitive subdivision, then, is retained. But in the Urodela, the separation is much less complete. While the sinus venosus, auricles, and ventricle resemble in general those of the Anura, the conus is usually much simpler. In the aquatic urodeles the spiral valve disappears more or less completely. The ultimate in degeneration is reached, indeed, in the aberrant lungless salamanders where not only is the conus undivided, but the interauricular septum is absent likewise. This represents a return to the original shark- or teleost-like condition.

I should like to suggest, then, that division of the chambers of the heart into right and left sides was accomplished as far back as the Crossopterygii and has been a feature of tetrapods in general since their origin; that modern Amphibia, with their incompletely divided hearts, illustrate a condition of degeneracy rather than one intermediate to fishes and amniotes as customarily taught. It would seem better, therefore, to limit laboratory studies to the heart of fishes and mammals. At least if the amphibian heart is studied, its position in the phylogenetic scheme of things should be clarified.

The Excretory System

The excretory organs of vertebrates consist of a large number of tubules which collect waste products and empty into a common drainage duct. Each tubule bears an intimate relation to the vascular system and ideally is in communication with the coelom. Comparative embryological data show that the tubules always are derived from the middlemost of the three divisions of embryonic mesoderm. The data also suggest that in the original vertebrates the kidneys extended the length of the coelom and were made up of segmentally arranged tubules, all alike and all open to the coelom. This hypothetical kidney has been designated an archinephros (holonephros) and its drainage duct the archinephric duct.

The tendency in modern vertebrates, however, has been for the tubules to exhibit increasing complexity from anterior to posterior. In fact, in amniote embryos all levels of the kidney forming tissues do not differentiate at the same time; rather they appear to develop in three groups, one behind the other both in time and space. These constitute, respectively, the pronephros, mesonephros, and metanephros. Although somewhat beside the point of this discussion, it is not amiss to point out, however, that distinctions made between these three groups of tubules have been unduly emphasized. It is always difficult to say where one group of tubules ends and the other begins; one grades imperceptibly into the other (Torrey, 1943). Further, modern experimental studies show that given certain circumstances, mesonephrogenic tissues may

form either pro- or metanephros. Such facts can only mean that the intermediate mesoderm is empowered to produce *a* kidney, not three. Originally all the tubules were alike, but conditions in the internal environment have led to progressive structural complexity. To put it another way, the intermediate mesoderm is competent to produce kidney tubules in a generic sense; the specific kind of tubule depends upon internal circumstances along the length of the body.

To return to the main theme, it is customarily said that in its evolutionary history the kidney parallels its ontogenetic history in amniotes. Accordingly, the myxinoid cyclostomes are described as having a pronephros and the fishes and amphibia as having a mesonephros (preceded by the embryonically provisional pronephros). As a matter of fact, the myxinoids come pretty close to presenting the ideal vertebrate archinephros. The myxinoid kidney extends the length of the coelom, that is, involves essentially all the nephrogenic mesoderm, and, except for the last few, the tubules are of the simplest grade. In terms of tubule structure it is a pronephros; but topographically it includes mesonephrogenic and metanephrogenic areas as well as pronephric. It is not the equivalent of the amniote pronephros at all; it is the spatial equivalent of all three amniote kidneys except that its tubules have attained only the pronephric grade of differentiation.

A similar situation prevails in the case of the so-called mesonephros of the adult fish or amphibian. The anterior end of the nephrogenic mesoderm differentiates into the pronephric grade and, with certain few exceptions, this pronephros disappears. The remainder, meaning the material which in amniotes will produce meso- and metanephros, then attains the mesonephric level of development. In terms of tubule structure it is a mesonephros; but in spatial terms it corresponds to both the meso- and metanephros of amniotes. It is not, therefore, the equivalent of the amniote mesonephros. Along with Miss Hyman, who has done so in the 1942 revision of her popular text and laboratory guide, I would favor the use of Graham Kerr's term opisthonephros to describe the adult kidney of fishes and amphibians.

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